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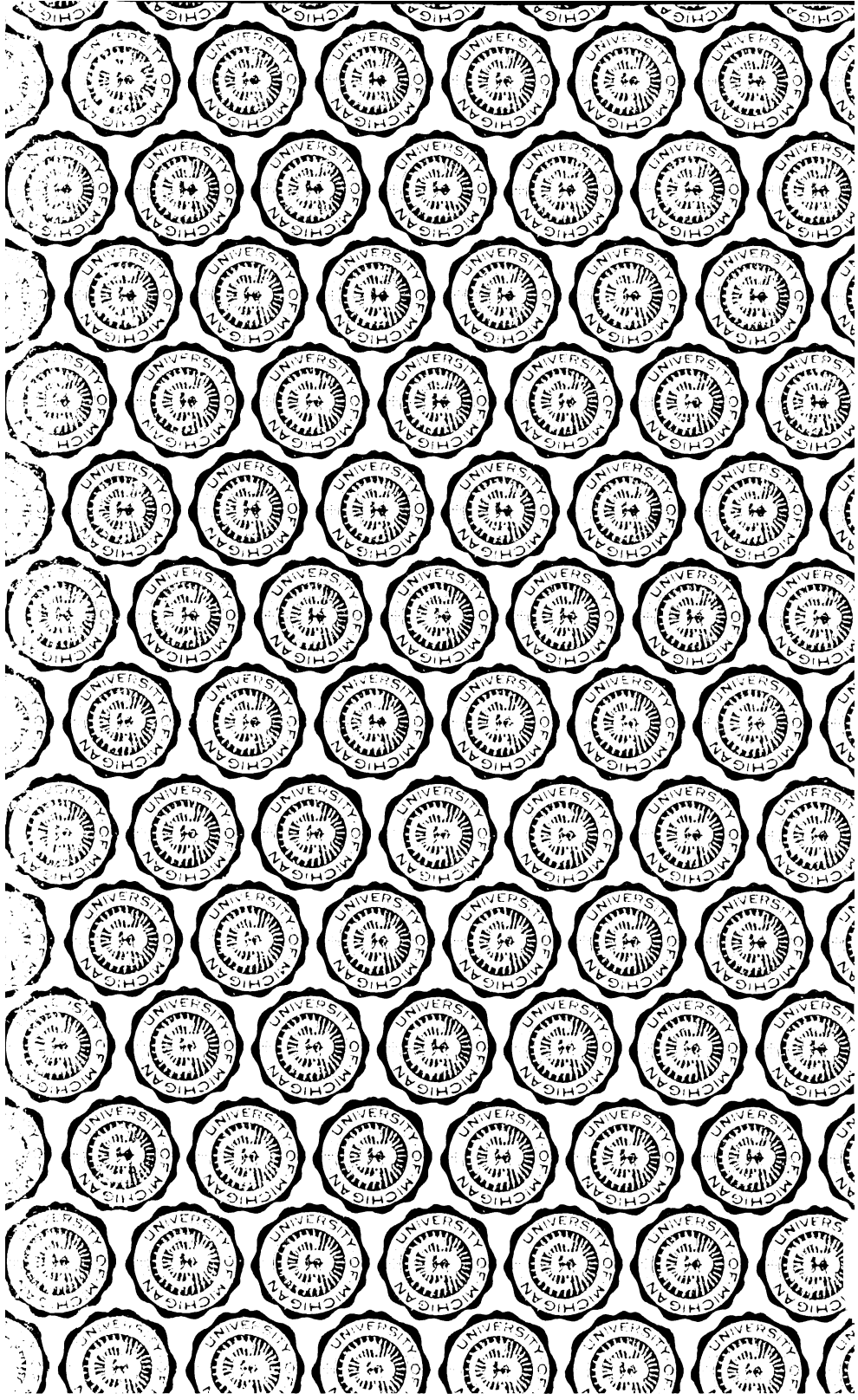
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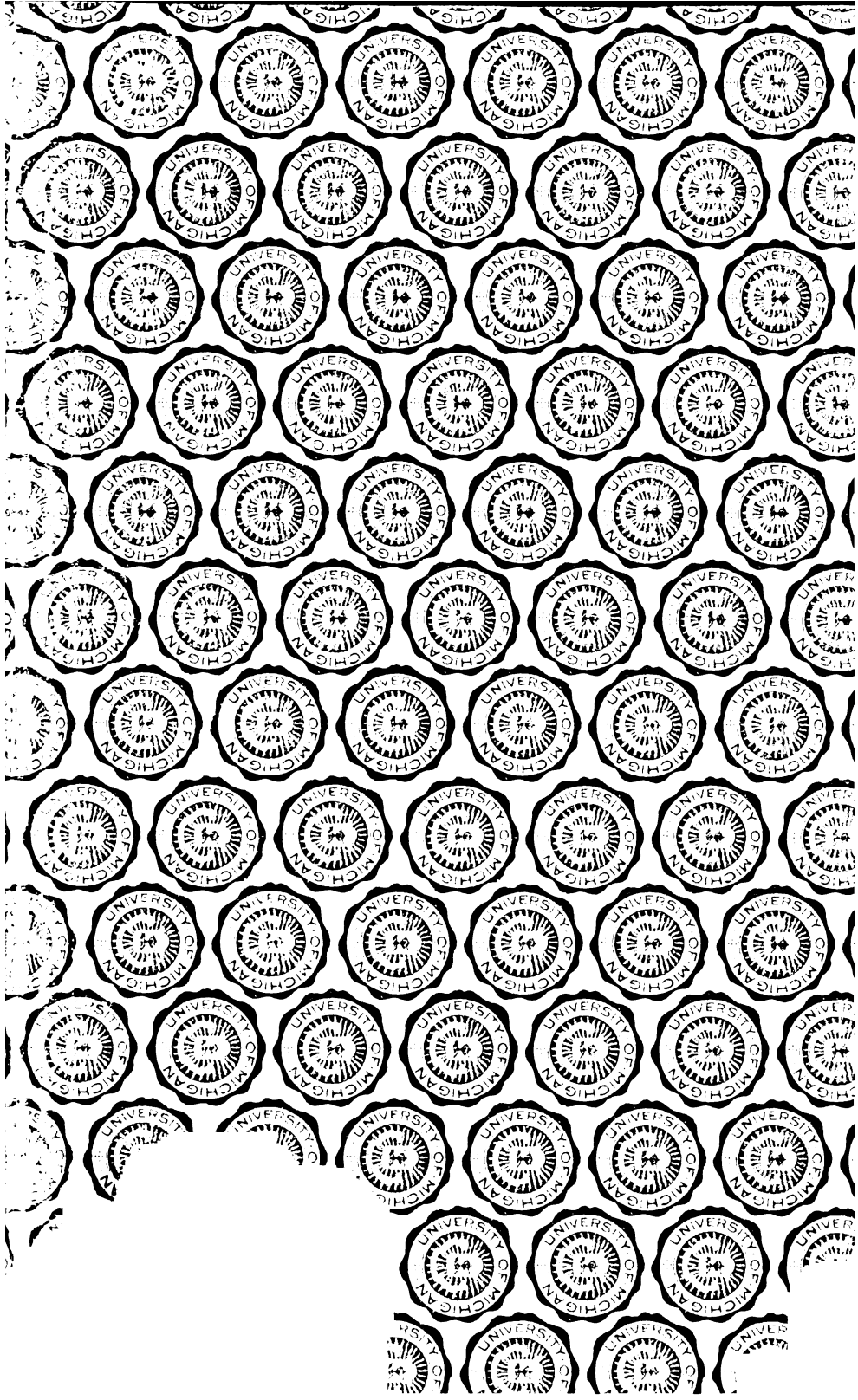
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THE CANADIAN

RECORD OF SCIENCE,

INCLUDING THE PROCEEDINGS OF

THE NATURAL HISTORY SOCIETY OF MONTREAL,

AND REPLACING

THE CANADIAN NATURALIST.

VOL. I. (1884-1885.)

MONTREAL:

PUBLISHED BY THE NATURAL HISTORY SOCIETY,

AND FOR SALE BY DAWSON BROTHERS.

1885.

EDITING COMMITTEE.

T. STERRY HUNT.
D. P. PENHALLOW.
B. J. HARRINGTON.
J. WANLESS.
J. T. DONALD.

All communications should be addressed to the Editors of THE CANADIAN RECORD OF SCIENCE, Natural History Museum, 32 University Street, Montreal.

This number replaces that issued under date of January, 1884, with the name of *The Canadian Record of Natural History and Geology, which is cancelled.*

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THE

CANADIAN RECORD OF SCIENCE

ERRATA, VOL. I.

Page 152. Reverse the numbering of Figs. 2 and 3, and in Reference, No. 1, for "$\frac{1}{3}$" read "$\frac{3}{1}$."
Page 174, line 7. For "*cinerera*" read "*cinerea*."
Pages 198, 9. In Tables for "Phospheric" read "Phosphoric."
Page 220, line 11 from bottom. For "7·560" read "7)·560."
Page 256, line 5 from bottom. For "Drugendorff" read "Dragendorff."

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THE

CANADIAN RECORD OF SCIENCE.

MONTREAL.

VOLUME I. ... ... NUMBER 1.

I. INTRODUCTION.

THE CANADIAN NATURALIST, of which the present journal is a continuation, first appeared in February, 1856, under the title of *The Canadian Naturalist and Geologist*, with the name of E. Billings as editor, and was published at Montreal, bi-monthly. After the first year there was added to its title the words, "*and Proceedings of the Natural History Society of Montreal*," it being at the same time announced that it was conducted by a committee of this Society, Mr. Billings remaining one of the editors.

Of this, the first series of the journal, eight volumes appeared, the last in 1863. In 1864 began a new series with the same title as before, still published bi-monthly and conducted by a committee of the Natural History Society, Mr. D. A. P. Watt being the general editor. In 1866 only two numbers of volume III. were published, and but one in 1867, the remaining three numbers appearing in 1868; so that this volume extends over the three years 1866-1868, though the journal still purported to be bi-monthly. With volume IV. the title was changed to that of *The Canadian Naturalist and Quarterly Journal of Science.* This volume was

published in 1869, and volume V. in 1870, the journal being edited, as before, by a committee of the Natural History Society. Of volume VI. two numbers appeared in 1871, and two in 1872. In 1873 the journal resumed its quarterly publication, but with half the number of pages, so that volume VII. was made to consist of eight numbers, and covered the two years, 1873-1874; Dr. B. J. Harrington becoming sole editor. Volume VIII. was again irregular in its publication, and its eight numbers extended over the four years, 1875-78. Volume IX. began in 1879, and the last number of it was not published till March, 1881. With volume X. Mr. J. T. Donald who, for the previous volume had been assistant editor, took charge of the journal, and of this volume the concluding number was published in July, 1883. The second series of ten volumes of the *Canadian Naturalist* thus extends over a period of more than eighteen years.

The present journal, which, under the title of THE CANADIAN RECORD OF SCIENCE, is to take its place, will be conducted as before, by a committee of the Natural History Society of Montreal, which will moreover publish the journal. It will, as far as possible, appear quarterly, and will make a volume of about five hundred pages once in two years, beginning May, 1884. Original and selected articles, more particularly those of especial interest to the country, will appear in its pages, and it is hoped that by the hearty co-operation of scientific workers throughout the Dominion THE CANADIAN RECORD OF SCIENCE may be made a worthy successor of *The Canadian Naturalist.*

Montreal, May, 1884.

II. The Royal Society of Canada.

This Society, which was founded in May, 1882, by His Excellency the Marquis of Lorne, held its second annual meeting in 1883, at Ottawa on the 22nd to 25th of May, inclusive, under the presidency of Principal Dawson of McGill College, Montreal.

The objects of the Society are: first, to encourage studies and investigations in literature and science; secondly, to publish transactions, annually or semi-annually, containing the minutes of proceedings at meetings, records of the work performed, original papers and memoirs of merit, and such other documents as may be deemed worthy of publication; thirdly, to offer prizes or inducements for valuable papers on subjects relating to Canada, and to aid researches already begun and carried so far as to render their ultimate value probable; fourthly, to assist in the collection of specimens, with a view to the formation of a Canadian Museum of archives, ethnology, archæology and natural history.

The members are entitled "Fellows of the Royal Society of Canada," and His Excellency the Governor-General is the Honorary President and Patron of the Society. The Society consists of the four following sections:—1. French literature, with history, archæology and allied subjects; 2. English literature, with history, archæology and allied subjects; 3. Mathematical, chemical and physical sciences. 4. Geological and biological sciences.

The officers of the Society are a president and vice-president, with an honorary secretary and treasurer, to be elected by the whole Society; besides a president, vice-president and secretary of each section, to be elected by the section. These elections are annual, and the officers so elected constitute the council of the Society. The members of the Society shall be persons residing in the Dominion of Canada or Newfoundland who have published original works or memoirs of merit, or have rendered eminent services to literature or science. The number of members in each section is limited to twenty. The Society may elect by ballot on proposal by three members, or on recommendation of the council, persons not resident in Canada as corresponding members. Such persons must be eminent in literature or science, and evidence to that effect must be presented to the Society at the time of their

proposal or recommendation. The number of corresponding members is limited to sixteen, and shall represent each section of the Society. The Society will meet annually in such city of the Dominion as it may determine from time to time, and may at any annual meeting appoint other meetings to be held in the course of the year. Every scientific or literary society in the Dominion which may be selected by vote of the Society will be invited by circular of the honorary secretary to elect annually one of its members as a delegate to the meetings of the Society; such delegate to have during his term of office the privilege of taking part in all general or sectional meetings for reading and discussion of papers, and to be empowered to communicate a short statement of original work done and papers published during the year by his society, and to report on any matters which the Royal Society may usefully aid, in publication or otherwise.

In addition to the Fellows of the Society, there were present delegates from the various scientific and literary societies of the Dominion, as well as from several societies of Britain and the United States.

THE REPORT OF THE COUNCIL

referred to the fact that a favorable answer had been received, through His Excellency the Governor-General, to the memorial to Her Majesty the Queen, asking her gracious permission to name the society the Royal Society of Canada, and to the fact that the act to incorporate the Royal Society of Canada had been passed by the Dominion Parliament (a draft of the bill being embodied in the report), and went on to state that a grant of $5,000 had been voted by the Dominion Parliament, and had been placed at the disposal of the Society. A circular to the officers of the Hudson's Bay Company, in relation to the collection of specimens in geology, natural history, ethnology, &c., had been forwarded to all the posts of the Company, but the practical effect of this circular would greatly depend on the ability of the Society to contribute to the expense of making collections and of transmitting them to Ottawa. Invitations to send delegates to the meeting had been sent to all the local societies in the Dominion and also to several English and foreign societies. A memorial had been addressed to the Government on the subject of the admission of

certain classes of scientific books and periodicals free of duty, and it was believed the action of Parliament in its last session would change some portions at least of the law complained of. The matter of uniform time had been committed to Mr. Sanford Fleming, to represent their views to the International Congress on the subject. At the meeting of the council, in December, 1882, the subject of regulations was taken up, and a draft prepared, which was printed and circulated to the members. The report recommended that, as it seemed likely that the British Association for the Advancement of Science would meet in Montreal in 1884, the Society should take measures to extend a welcome to the Association, and to be represented by as many as possible of its members on the occasion.

On motion of Mr. Faucher de St. Maurice, it was resolved to ask the Government, through the Minister of Marine and Fisheries, that such specimens of the Canadian fishery exhibit now at the International Fishery Exhibition, in London, England, as are of scientific value, should be offered to the National Museum.

His Excellency the Governor-General then delivered the following address to the Society :

When we met last year, and formally inaugurated a society for the encouragement of literature and science in Canada, an experiment was tried. As with all experiments, its possible success was questioned by some, who feared that the elements necessary for such an organization were lacking. Our meetion of this year assumes a character which an inaugural assembly could not possess. The position we took in asserting that the time had come for the institution of such a union of the scientific and literary men of this country has been established as good, not only by the honorable name accorded to us by Her Majesty—a designation never lightly granted—but also by that without which we could not stand, namely, the public favors extended to our efforts.

Parliament has recognized the earnest purpose and happy co-operation with which you have met, and worked in unison. Knowing that the talents exhibited are not those of gold and silver only, it has stamped with its approbation your designs by voting a sum of money, which in part will defray the expense of the printing of your transactions. And here, in speaking of this as a business-meeting, I would venture to remind you, and all

friends of this Society throughout the country, that the $5,000 annually voted by the House of Commons will go but a very short way in preparing a publication which shall fully represent Canada to the foreign scientific bodies of the world. We have only to look to the Federal and State Legislatures of America to see what vast sums are annually expended by the State for scientific research. We see there also how the proceeds of noble endowments are annually utilized for the free dissemination of knowledge. It is therefore not to be supposed that the comparatively small pecuniary assistance provided by any government-grant can absolve wealthy individuals from the patriotic duty of bequeathing or of giving to such a national society the funds without which it cannot usefully exist.

You will forgive me, as one who may be supposed to have a certain amount of the traditional economical prudence of his countrymen, for mentioning one other matter, on which at all events, in the meantime, a saving can be effected. While it is necessary to have accurate and finely executed engravings of beautiful drawings for the illustration of scientific papers, it is necessary that the printing of the transactions should occasion as little cost as possible, and I believe you will find it advisable for the present that each paper shall be printed only in that language in which its author has communicated it to the Society. Your position is rather a peculiar one, for although you work for the benefit of the public, it is not to be expected that the public can understand all you say when your speech is of science in consultation with each other. The public will, therefore, I trust, be in the position of those who are willing to pay their physicians when they meet in consultation, without insisting that every word the doctors say to each other shall be repeated in the hearing of all men. When funds increase it seems to me that the economy it will probably now be necessary to exercise in regard to this may be discarded.

In the sections dealing with literature, it is proposed to establish a reading-committee, whose duty it shall be to report on the publications of the year, that our thanks may be given to the authors who advance the cause of literature among us. To assist in that most necessary enterprise, the formation of a National Museum, circulars have been addressed by the Society to men likely to have opportunities for the collection of objects of interest,

and the Hudson's Bay Company's officers have been foremost in promoting our wishes. The Government is now prepared to house all objects sent to the Secretary of the Royal Society at Ottawa, and contributions for collections of archives, of antiquities and of zoology, and of all things of interest, are requested. I rejoice, gentlemen, that I have been able to be with you now that a year has elapsed since our inauguration, as this period allows us in some measure to judge of our future prospects. These are most encouraging, and the only possible difficulty that I can see ahead of you is this: that men may be apt to take exception to your membership because it is not geographically representative. I would earnestly counsel you to hold to your course in this matter. A scientific and literary society must remain one representing individual eminence, and that individual eminence must be recognized if, as it may happen accidentally, personal distinction in authorship may at any particular moment be the happy possession of only one part of the country. A complete work, and one recognized for its merit, should remain the essential qualification for election to the literary sections, and the same test should be applied, as far as possible, to the scientific branches. If men be elected simply because they came from such and such a college, or if they be elected simply because they came from the east, from the west, from the north, or from the south, you will get a heterogenous body together, quite unworthy to be compared with the foreign societies on whose intellectual level Canada, as represented by her scientific men and authors, must in future endeavor to stand.

One word more as to the kindly recognition already given to you. In America, in France, and in Britain, the birth of the new institution has been hailed with joy, and our distinguished president is at this moment also a nominated delegate of Britain. An illness we deplore has alone prevented the absence of an illustrious member of the Academy of France; and the French Government, with an enlightened generosity which does it honor, had expressed its wish to defray the expenses of the most welcome of ambassadors. We have the satisfaction of cordially greeting an eminent representative of the United States, and we express the desire, which is shared by all in this hall, that our meeting may never want the presence of delegates of the great people who are dear as they are near to us.

It is, gentlemen, greatly owing to your organization that the British Association for the Advancement of Science will next year meet at Montreal, following in this a precedent happily established by the visit last year of the American Association. These meetings at Montreal are not without their significance. They show that it is not only among statesmen and politicians abroad that Canada is valued and respected, but that throughout all classes, and wherever intellect, culture and scientific attainments are revered, her position is acknowledged, and her aspiration to take her place among the nations is seen and welcomed.

I am sure that your British brethren have chosen wisely in selecting Montreal, for I know the hearty greeting which awaits them from its hospitable citizens. The facilities placed at the disposal of our British guests will enable them to visit a large portion of our immense territory, where in every part new and interesting matters will arrest their attention, and give delight to men who in many cases have but lately realized our resources. Their words, biased by no interests other than the desire for knowledge, and founded on personal observation, will find no contradiction when they assert that in the lifetime of babes now born the vast fertile regions of Canada will be the home of a people more numerous than that which at the present time inhabits the United Kingdom.

I must not now further occupy your time, but would once more ask you to accept my heartfelt thanks for the determination shown by all to make the Royal Society a worthy embodiment of the literary activity and scientific labor of our widely-scattered countrymen throughout this great land.

PRINCIPAL DAWSON, in replying, referred to the kind and generous manner in which the last meeting of the Society had been treated by the people and press of Canada, and to the faith apparently entertained by the people that Canada is capable of sustaining such a Society. He then noticed the various points of progress during the recess—the gracious permission of Her Majesty to assume the title of the Royal Society of Canada, and the obligations thereby imposed; the incorporation of the Society by Act of Parliament and the grant in aid of its publications; the movement toward the beginning of a national museum, the new feature in the meeting arising from the presence of delegates from local societies, and the advantage accruing therefrom:

the courteous replies given by societies abroad, and the presence of delegates from some of them, and the probable influence of the contemplated visit of the British Association on Canadian science. He also referred to the care which would be taken with regard to expenditures on publications. He next noticed the removal by death of one of the members of the Society, Mr. George Barnston, and paid a tribute of respect to his personal worth and valuable services to Canadian science.

The remainder of the address was occupied with remarks on the progress of Canadian science, considered as embracing the two great branches of experimental and observative investigation. In chemistry and meteorology Canada had made greater progress, and was better provided with means of research than in physics and astronomy; but appliances were increasing, and the educational activity in these branches gave the prospect of greater progress in the future. In geological and biological science the most important public provision was that furnished by the Geological Survey, which had the great advantage of being general rather than provincial, but was not as yet adequately provided for, either in buildings or means, and should have a greater amount of independence. Private research in geology and natural history had naturally made more progress than in most other departments, but there was a boundless field for exploration and study which had as yet been merely touched, and as there were educational facilities in abundance it was hoped that the number of scientific collectors and investigators would increase. In all these departments it was the function of the Society to aid, stimulate and encourage, and to afford scope for discussion and for publication.

In conclusion, he referred to the connection of science with literature. The two departments were in this Society intimately associated, the literary sections being in some sense scientific as well. Science has a literature of its own, great and increasing, and which competes with history and fiction for the popular eye and ear. Nature, rather than art, is the foundation of the best literature. It is on this, rather than in the graces of composition, or the tricks of style, or the flowers of imagination, that enduring literary fame must be built. This is especially the case in this country where history has been and will be marked out by its physical features and resources, and where our real poetry is that of our great rivers and vast lakes, our boundless plains, our

solitudes and changeful climate. These are unwritten poems which have impressed themselves on the minds of our people more than anything man has yet said or done, and he who most truly interprets these great unwritten histories and poems will build up the most lasting fame. For this reason he rejoiced that the Society embraced both literature and science, and he was profoundly convinced that it was for the highest interest of Canada that, while its scientific men should be men of culture, its literary men should be men of scientific knowledge and scientific habits of thought.

Hon. Dr. Chauveau, Vice-President of the Society, followed in French. He said that this was almost the second inauguration of the Royal Society, which had been already founded and inaugurated by His Excellency the Governor-General, but which had since obtained permission from Her Majesty to assume the name of the Royal Society, which it was doing most auspiciously now under the joint presidency of His Excellency and Her Royal Highness. He said that the very excellent remarks of His Excellency and the most exhaustive address of the President, Principal Dawson, did not leave him much to say; still he would point out two great and most desirable results of the establishment of this Society. One was to make our literature and our scientific exertions more widely known in other countries, and the other, which was perhaps more difficult to obtain, was to make the two great elements of this country, French and English, better known to each other.

Several comparisons had been resorted to in order to illustrate the estrangement which had so long existed between these two sections in many respects, as well as in those of literature and science. Not unfrequently the two races had been compared to the waters of the Ottawa and the St Lawrence, which ran for a long time side by side without mixing together—but still they mixed. He himself had alluded elsewhere to the famous staircase of the historical château of Chambord, which was so constructed that two persons could ascend at the same time without seeing each other, it being a kind of double staircase, and in the progress which these two races made towards their common destiny they also seemed in many respects to ignore each other, meeting occasionally on the political platform.

This Society would have the effect of bringing together men from all parts of the country, who have followed various pursuits in the world of science and literature. He noticed with pleasure in the list of papers to be read in the section of English Literature, one on French Canadian literature, by Mr. John Lesperance, an Anglo-Canadian writer with a French name. He was almost ashamed that the French section had allowed itself to be distanced in that courteous move, and could only account for it perhaps by the fact that as a good deal of criticism was always mixed up with any literary review his section had perhaps acted in accordance with the famous word at Fontenoy, "*Messieurs les Anglais, tirez les premiers.*" He hoped, however, that Mr. Lesperance's action would meet with reciprocity, and no one could do better in the French section than Mr. Oscar Dunn, a French *littérateur* with an English name.

In anticipation of this he would say a few words on Anglo-Canadian literature. He then alluded to the poems of Adam Kidd, the Huron chief, and to the subsequent poems of Heavysege, Sangster, Reade, Murray, and the works of Mrs. Leprohon, another English writer with a French name. He also referred to the works of Kirby, Lesperance, and Mrs. Moody, as well as to the works in prose of Dr. Ryerson, Mr. Dent and others. He concluded by alluding to the reception which the invitations of the Society had received abroad, and especially to the response made by the Académie Française, and praised the conduct of the French government in offering to defray the expenses of a delegate. He spoke in warm terms of M. Marmier as an old friend of Canada, who had accepted the choice made of him by the Academy, and regretted that a gentleman who had been in Canada nearly forty years ago, and who had ever since shown a strong interest in Canada and Canadians, could not, on account of sudden illness, be present. M. Marmier had done much in making Canada known, and especially in recommending to the French Academy the works of Mr. Fréchette, the poet laureate of Canada.

The proceedings of the sections devoted to the sciences will naturally be of interest to our readers, and therefore we give a *resumé* of them.

SECTION III—MATHEMATICAL, PHYSICAL AND CHEMICAL SCIENCES.

Mr. Sanford Fleming made some remarks on the adoption of a universal meridian for the regulation of time, and pointed out that the memorial of the Society at its last meeting, requesting that Canada should be represented at the International Conference to be held on this subject, at the invitation of the President of the United States, had not been responded to.

A motion was adopted, recommending to the Council the appointment of a committee for the purpose of co-operating with other societies and carrying out this system, and the adoption of a memorial to His Excellency, asking that the Imperial government may be moved to have Canada represented at the conference in question.

Prof. Johnson, of Montreal, gave an account of the preparations which were made at McGill University for the observation of the late transit of Venus, and read a report from Prof. McLeod of the observations which were successfully made at Winnipeg.

The secretary, Prof. Cherriman, read a report from Mr. Carpmael of Toronto, to the Minister of Marine and Fisheries on the same subject, recording the preparations made in Canada and including the reports of the observations at Cobourg, Ottawa, Kingston and Winnipeg, which were the only stations where the observations were wholly or partially successful.

Prof. Williamson gave a verbal account of the observations which were made by him at Kingston.

Dr. Ellis, of Toronto, gave an account of a remarkable sulphur-spring near Port Stanley, and also an explanation of the method by which the tannin-determination of Lowenthal might be made valuable for the detection of impurities or adulterations in spices.

Mr. F. N. Gisborne read a paper on recent improvements in practical telegraphy.

Mr. T. Macfarlane read a paper on the decomposition of zinc-sulphate by common salt.

Dr. T. Sterry Hunt discussed the mechanical transfer of matter in the process of segregation, on which an interesting discussion arose, Mr. Macfarlane illustrating the subject by reference to the kernel-roasting of copper-bearing iron-pyrites as seen in the ore-heaps at Lennoxville.

Prof. McGregor, of Halifax, Nova Scotia, read a paper on the variation of the polarization of electrodes with their difference of potential.

Prof. Harrington, of McGill University, Montreal, described two species of minerals new to Canada—meneghinite from Ontario, and tennantite from the Eastern Townships.

Dr. Ellis presented a specimen of tellurium found in the gold ores of Lake Superior, the first discovery of tellurium in Canada.

Mr. Baillargé, read a paper entitled "Hints to Geometers for a new edition of Euclid."

Dr. Haanel, of Victoria College, Cobourg, communicated a paper on the application of hydriodic acid as a blow-pipe reagent. A new process was described in which this acid is used with a blow-pipe flame on tablets of plaster-of-Paris for determining the character of minerals. A number of water-color drawings were exhibited, showing a beautiful series of characteristic colored sublimates on these plaster tablets, proving that a large number of elements and even of compound minerals can thus be determined by their action with hydriodic acid.

Prof. Dupuis, of Kingston, described a mode of construction by which a sidereal clock could be made to show mean time also.

Capt. Deville read a paper on the measurement of terrestrial distances by astronomical observations, which proposed to substitute the difference of azimuths instead of, as usual, the difference of latitudes.

Mr. Macfarlane read a paper on the reduction of sulphate of soda by carbon.

Mr. Baillargé contributed papers on the following subjects: On simplified solutions of two of the more difficult cases in hydrographic surveying; and The measurement of surveys by spherical triangles and polygons on a sphere of any radius; the latter in the French language.

SECTION IIII—GEOLOGICAL AND BIOLOGICAL SCIENCES.

Dr. Selwyn read a paper, entitled "Notes on the Geology of Lake Superior." The points insisted on by Dr. Selwyn were: the conformity of the Laurentian and Huronian divisions of the older crystalline rocks, the Lower Cambrian age of the upper copper-bearing rocks of Logan, called Animikie, Nepigon and Keweenian by Dr. Hunt, and the unconformity of the Animikie divisions

to the underlying Huronian, by some geologists in the United States supposed to be of the same age.

Mr. W. Saunders, of London, Ont., read a paper "On the influence of Sex on Hybrids among Fruits." This paper gave some of the results of Mr. Saunders' experience in hybridizing fruits. The facts cited confirmed the view that the influence of the female is more strongly expressed in the habit, character of growth and constitution of the plant, while the influence of the male is more distinctly seen in the form, color and quality of the fruit, and, in the case of hybrid grapes, in the size and form of the seeds also.

A paper by Mr. G. F. Matthew, of St. John, N. B., on "The Method of distinguishing Lacustrine from Marine Deposits," was read by Prof. Bailey, of Fredericton.

Dr. Grant, of Ottawa, read a communication on "The Inferior Maxilla of the Phoca Grœnlandica, from Green's Creek near Ottawa."

Principal Dawson, of Montreal, read a note on "Spores and spore-cases, from the Erian formation," giving results which are set forth more at length in a paper in this number, on "Rhizocarps in the Palæzoic Period."

Professor Bailey read a paper on the folding of the carboniferous strata in the Maritime Provinces by Mr. E. Gilpin, jr. After a preliminary sketch of the carboniferous measures of the Lower Provinces, the writer described each of its great subdivisions as exposed at various points. The lower coal-measures are met in southern New Brunswick as fine sediments and grits, and resemble the same measures as found at Horton and elsewhere. They are represented in Cape Breton county and in Newfoundland by great beds of conglomerate. Sections show a line of minimum deposition along the Cobequids to Cape George, and thence through Bras d'Or to Cape Ray. The carboniferous limestones are described as passing into the succeeding measures, except at places in Cape Breton and southern New Brunswick, where they were folded before the millstone-grit period. The greatest depression of this period would appear to have been in the Richmond district, and to have gradually diminished to the north-west and north-east. The points of maximum accumulation appear to have been at the Joggins and in Richmond county. These measures in Newfoundland and Cape Breton pass regularly into the succeeding coal-measures. In Pictou County they were extensively folded before the later measures were

formed. The folding of the coal-measures and of the succeeding measures were referred to, and the opinion was advanced that comparatively little folding of the carboniferous had taken place in the Lower Provinces since the close of the trias. During the carboniferous period, in addition to the continental changes of level giving rise to conditions of deposition characterizing the carboniferous limestone, millstone-grit, etc., there were extensive foldings of a more local character, apparently in some cases marking the closing of these oscillations. These foldings and their subsequent denudations have played an important part, hitherto but little studied in modifying the conditions arising from the larger and more extended movements which have hitherto principally received attention, and show the district to have been far from quiet during the carboniferous age.

Professor R. Bell's paper on the causes of the fertility of the land in the Canadian Northwest territories was of great interest. The author, after referring to the various processes by which soils in general are formed, pointed out the reason for the fertility or otherwise of great districts in the older provinces. In the Canadian Northwest a vast fertile tract stretches, with certain exceptions, from the Red River Valley to the Liard River, a distance of some fourteen hundred miles. The soil of this tract was characterized as a dark loam, of varying depth, and of a nearly homogeneous consistency. The primary cause of the fertility of this region was the abundance of the underlying crude material out of which a finished soil could be made. This was derived partly from the wide-spreading cretaceous marls, which were nearly co-extensive with the fertile tract, and partly from the drift during the glacial period. Dr. Bell next considered the process by which the black loamy soil was formed out of this subsoil, and he considered that the main agency was the work of moles and other burrowing animals. Darwin had proved that in England and some other countries earth-worms played the chief part in the formation of the vegetable mould. These worms appeared to be absent in the Northwest, owing principally to the frost penetrating into the ground beyond the depth to which worms can burrow, but the moles and the ground-squirrels or gophers more than make up for their absence. In the fertilized tracts the old and new mole-hills cover the whole surface, rendering it hummocky, which may be easily observed after the prairie has been swept by

a fire. The badgers often did what was compared to subsoil ploughing. All the animals referred to were very active in the autumn, digging many more burrows than appeared to be of any use to themselves. Each hummock thrown up by the moles covered about a square foot, and buried all the grass, etc., on this space. In this manner large quantities of vegetable matter were ultimately incorporated with the soil. The work of the moles also acted in another way, in refining the soil, for they left behind the stones and coarse gravel, so that these in time became sunk beneath the layer of mould produced. By a fortunate coincidence, at the season when the burrowing animals are most active, the prairie-vegetation is mature, and contains the largest amount of useful substances. The coldness of the soil during the most of the year tended to preserve the organic matter in it, while the circumstances given were the direct cause of the fertility. The ultimate reason was perhaps to be looked for in the climate of the Northwest, for to this were due the growth of the vegetation which formed the manure and the food of the little workers which mingled it with the soil. Thus we could trace a mutual dependence of the circumstances which together have given to our Northwest Territories that surpassing fertility of soil which cannot fail to attract to it a vast population.

The reading of this paper was followed by a very interesting discussion. Dr. Selwyn corroborated what the author had said as to the phenomena and their vast importance in an economic point of view.

Prof. Macoun considered that the chief cause of the fertility of the soil was owing to the action of the frost on its rocky constituents, to which Dr. Bell replied that this did not account for the introduction of the organic matter, and that on this the fertility mainly depended. If the fertility were in proportion to the frost, then the Arctic regions should have the richest soil, which was not the case.

Dr. Dawson mentioned that stratified superficial deposits were found in various parts of the Northwest. The author said he had referred to these in his paper as due to the transient action of water during a submergence of the land, but that this was not a material part of the question.

In reply to a request, Professors Bell and Macoun described the various burrowing animals which had been mentioned.

Dr. G. M. Dawson then read a paper entitled "Notes on Triassic Rocks of the West," after which Prof. Bailey gave an interesting address on the occurrence of Indian relics in New Brunswick.

Dr. T. Sterry Hunt read a paper entitled "Studies on Serpentine Rocks," and by title one on the Taconic Question in Geology, and Prof. Macoun one entitled "Notes on Canadian Polypetalæ."

LIST OF PAPERS PRESENTED IN SECTIONS III. AND IV. AT THE MEETING OF THE ROYAL SOCIETY OF CANADA, MAY, 1883.

Section III. Mathematical, Physical and Chemical Sciences.

1. Prof. McGregor:—On the independence of the Electromotive Force of Polarization of the difference of Potential of the Electrodes.

2. Prof. Harrington:—On some Minerals new to Canada.

3. Mr. Baillargé:—(I.) Hints to Geometers for a New Edition of Euclid;

4. (II.) Simplified Solution of two of the more difficult cases in the parting off or dividing up of land; also a case in Hydrographical Surveying;

5. (III.) Le toisé des surfaces des triangles et polygones sphériques sous un rayon ou diamètre quelconque.

6. Prof. Haanel:—On the Application of Hydriodic Acid as a Blow-pipe Reagent.

7. Prof. Dupuis:—A Mechanical Arrangement for making a Sidereal Clock show also mean time.

8. Capt. Deville:—The Measurement of Terrestrial Distances by Astronomical Observations.

9. Mr. T. Macfarlane:—(I.) On the Reduction of Sulphate of Soda by Carbon;

10. (II.) On the Decomposition of Zinc-Sulphate by Common Salt.

11. Prof. Johnson:—An Account of the Preparations at McGill College for Observing the late Transit of Venus.

12. Mr. Gisborne:—Recent Improvements in Practical Telegraphy.

13. Mr. Sanford Fleming:—On the Regulation of Time and the Adoption of a Universal Prime Meridian.

14. Dr. T. Sterry Hunt:—On the Mechanical Transfer of Matters in the Process of Segregation.

15. Prof. Chapman:—(I.) On Cryptomorphism in its relations to Classification and Mineral Types;

16. (II.) A suggestion respecting Spectroscopic Scales.

In addition to the sixteen papers above mentioned by members of the section, the following were also read:—

1. Dr. Ellis:—(I.) Analysis of the Water of a Sulphur Spring near Port Stanley, Ont.

2. (II.) Some Applications of Lowenthal's Method of Tannin Estimation.

3. Prof. Coleman (read by Prof. Haanel):—Spectroscopic examination of the coatings obtained by the treatment of certain substances with Hydriodic Acid in blow-pipe analysis.

4. Prof. McLeod (read by Dr. Johnson):—Report of Observations of the Transit of Venus at Winnipeg.

Section IV. Geological and Biological Sciences.

1. Dr. Selwyn:—On the Geology of Lake Superior.

2. Wm. Saunders:—On the Influence of Sex on Hybrids among Fruits.

3. Prof. Macoun—Notes on the Flora of the Gaspé Peninsula.

4. Edwin Gilpin, jr.:—The Folding of the Carboniferous in the Maritime Provinces.

5. Dr. G. M. Dawson:—Note on the Triassic of the Rocky Mountains and British Columbia.

6. G. F. Matthews:—(I.) On the Method of Distinguishing Lacustrine from Marine Deposits;

7. (II.) Illustrations of the Fauna of the St. John group; part 2.

8. The Abbé Laflamme:—Note sur la Géologie du lac Saint Jean.

9. R. Chalmers (communicated by Principal Dawson):—On Erosion from Coast and Floating Ice in the Baie des Chaleurs District.

10. Dr. J. A. Grant:—On the Superior Maxilla of *Phoca Grœnlandica*, from Green's Creek, Gloucester, County Russell, Ont.

11. Prof. Macoun :—Notes on Canadian Polypetalæ.

12. Principal Dawson :—On Spores and Spore-cases from the Erian Formation.

13. Dr. R. Bell :—On the Causes of Fertility of the Land in the Canadian North-West.

14. Prof. Chapman :—A new classification of Crinoids.

15. (I.) Dr. T. Sterry Hunt:—Studies of Serpentine Rocks;

16. (II.) The Taconic Question in Geology.

17. Rev. Dr. Honeyman :—On the Triassic and later Geological formations of the Eastern United States and British America.

18. Prof. L. W. Bailey :—On the occurrence of Indian remains in New Brunswick

19. J. F. Whiteaves:—Some recent additions to the fauna of the Hamilton group in Ontario.

III. On Rhizocarps in the Palæozoic Period

By J. W. Dawson of Montreal.

(*Read before the American Association at Minneapolis, Aug.* 16, 1883.)

Some years ago my attention was directed by the late Sir W. E. Logan to a shale from the Erian formation of Kettle Point, Lake Huron, supposed to be on the horizon of the Marcellus shale of New York, and which was filled with minute brownish discs, scarcely more than an hundredth of an inch in diameter, and which I recognized as probably spore-cases of macrospores of some acrogenous plant. They were described in some detail in a paper on "Spore-cases in Coal," published in the *American Journal of Science*, for April, 1871, and reprinted in the *Canadian Naturalist*, new series, Vol. V.

They were described as "flattened disc-like bodies, slightly papillate externally, and with a minute point of attachment at one side and sometimes a slit more or less gaping at the other. Viewed under the microscope as transparent objects, they appear yellow like amber, and show little structure, except that the walls can be distinguished from the internal cavity, and the latter is seen in places to contain patches of granular or flocculent matter."

They occur in a brown bituminous shale, which burns with much flame. This bed is stated in the report of the Geological Survey of Canada to be twelve to fourteen feet in thickness, but whether the fossils are equally abundant throughout its thickness is uncertain. The shale also contains vast numbers of rounded transparent granules, which may be escaped spores or microspores.

The only other fossils found in this bed are stems of a species of *Calamites* (*C. inornatus*), and a *Lepidodendron* obscurely preserved, but not improbably the *S. primaevum* of Rogers. My impression at the time when these spore-cases were first examined was that they might have been produced by a *Lepidodendron* or other lycopodiaceous plant.

In July, 1882, my attention was again directed to the subject by Prof. Orton, of Columbus, Ohio, who mentioned to me the occurrence of similar bodies in vast numbers in the Erian and Lower Carboniferous shale of Ohio, known as the Huron, Cleveland and Berea shales. Prof. Orton regarded these bodies as spore-cases, and was disposed to consider them as a main source of the bituminous matter so abundant in these formations in Ohio. He subsequently detailed his observations at the meeting of the American Association at Montreal, and referred to certain thread-like branching stems found with these bodies as possibly connected with them. Though this observation did not seem to be absolutely certain, yet in connection with the very wide distribution of the organisms in marine beds it served to shake the belief which I had formerly entertained as to the lycopodiaceous affinities of the *Sporangites Huronensis*, which on comparison I found some of Prof. Orton's specimens precisely resembled

For the geological facts relating to the mode of occurrence of the Ohio specimens, I may refer to Prof. Orton's paper, which appears in the proceedings of the American Association; merely stating that he describes the *Sporangites* as occurring throughout the thickness of the Ohio black shale, amounting to 250 to 300 feet, and which extends over a very wide area in Ohio and the neighbouring states.

At the meeting of the American Association, in the discussion of Prof. Orton's paper, Prof. Williams, of Cornell University,

mentioned that he had found similar bodies in the Hamilton shales of New York, and that they were associated with the curious pinnately leaved plant, *Ptilophyton Vanuxemi*, an observation to which I subsequently referred in discussing the affinities of this plant, in a report to the Geological Survey on the Erian plants of Canada, published in 1882.* Prof. Williams was kind enough to send me specimens, in which, however, the round spore-case like bodies were much less distinct than in the specimens from Ohio and Lake Huron. In the report above referred to I have also noticed the occurrence of rounded spore-like bodies in association with the stems of *Trochophyllum* of Lesquereux from the Lower Carboniferous of Pennsylvania, and of which specimens were submitted to me by Mr. Lacoe of Pittston, and Prof. Lesquereux. *Trochophyllum* I regard as closely allied to or perhaps congeneric with *Ptilophyton*, and in the report already referred to have argued that these plants were probably aquatic.

Still more recently Prof. J. M. Clarke, of Northampton, Massachusetts, was so kind as to send me two fragments of rock containing *Sporangites* similar to those above mentioned—one from the Genessee shale of Canandaigua, N.Y., and another from the Corniferous limestone. In the latter these bodies retain their globular form, though some are partially crushed in such a way as to show their membranous character. In slices prepared by Prof. Clarke the wall is seen to be thin and carbonaceous, with indications of a dense cellular structure, and some of the specimens show a projecting aperture or point of attachment at one side, giving them a somewhat pear-shaped appearance. The size of all these macrospores from the Erian of New York is nearly the same with that of Lake Huron specimens. Those found with *Trochophyllum* in the Lower Carboniferous are much larger.

No certain clue seemed to be afforded by all these observations as to the precise affinities of these widely-distributed bodies; but in March last Mr. Orville Derby, of the Geological Survey of Brazil sent me specimens found along with fronds of *Spirophyton* in the Erian of that country, which seemed to throw a new light on the whole subject. Mr. Derby's specimens recalled to remembrance certain fossils which had been sent to me several years

* Report on Erian Plants of Canada. Part II.

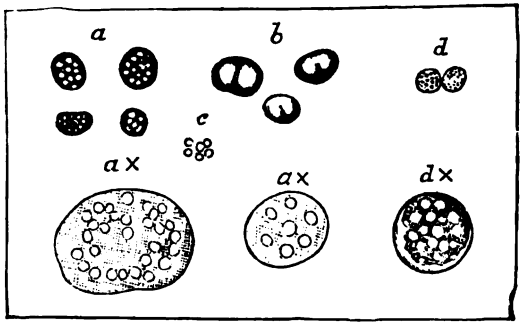
ago by the late Prof. Hartt, and which, like Mr. Derby's specimens, occurred in beds holding *Spirophyton*, though these were at that time regarded as Carboniferous. In a note prepared for Prof. Hartt, but not, so far as I am aware, published, I had noticed these fossils as follows :—

"*Sporangites*—Specimens from a shale at Rio Tapagos, above Haituba. These are spore-cases, probably of a Lepidodendroid plant, and appear similar to those described by Carruthers as found in cones from Brazil, referred by him to his genus *Flemingites*.* Carruthers' specimens were from Rio Grande du Sul, and were found in shales associated with beds of coal, and believed to be of Carboniferous age, though the fossils leaves found with them and attributed to the genera *Noeggerathia* and *Odontopteris* would, if interpreted by North American analogies, he supposed to be older than the true coal-formation. The present specimens are labelled as Carboniferous, but the occurrence in them of abundant fronds of *Spirophyton* rather points to a Devonian date."

Mr. Derby's specimens contain *Spirophyton*, and also minute rounded *Sporangites* like those obtained by Prof. Hartt. But they differ in showing the remarkable fact that these rounded bodies are enclosed in considerable numbers in spherical and oval sacs, the walls of which are composed of a tissue of hexagonal cells, and which resemble in every respect the involucres or spore-sacs of the little group of modern acrogens, known as Rhizocarps, and living in shallow water. More especially they resemble the sporocarps of the genus *Salvinia*. This fact opens up an entirely new field of investigation, and I would now proceed to describe these interesting specimens, to inquire as to their probable affinities with modern plants and their probable relations to other palæozoic forms of vegetation found with them.

Mr. Derby's specimens are labelled as from Rio Trombetas and Rio Curuà. They occur in two kinds of matrix. One is a thinly laminated sandy shale, tinged red with peroxide of iron, and with occasional ferruginous laminæ. In this the spore-sacs are flattened and black, and show the structure of the walls under the microscope. The contained macrospores, when visible, appear as minute tubercles or sometimes as depressions on the wall of the envelope, or more frequently as round light-coloured spots, according to their state of preservation (fig. 1 *a*). The other kind of

matrix is a gray dense shale in which the spore-sacs appear less flattened and destitute of carbonaceous matter.



(*a*) *Sporangites Braziliensis*, nat. size; (*a* ×) same, magnified.
(*b*) *Sp. bilobatus*, nat. size.
(*c*) Detached macrospores.
(*d*) Spore-cases of *Salvinia natans*; (*d* ×) the same magnified.

The very numerous spore-sacs contained in these shales are extremely variable in size and form, and may have belonged to several species of plants. They resolve themselves, however, into two leading types, which may be provisionally named *Sporangites Braziliensis* and *S. bilobatus*; though I would suggest for them, in prospect of the discovery of their vegetative parts, the name *Protosalvinia*. They may be described as follows:—

Sporangites (*Protosalvinia*) *Braziliensis*, S. N. (fig. 1 *a*), Sporocarps thin, carbonaceous, having a structure of dense hexagonal cells and enclosing macrospores which vary in number from three or four to as many as twenty-five; form circular, oval or reniform. Longest diameter from three millimetres to six millimetres. Some of the sacs which do not show included round bodies may have held microspores.

S. (*P.*) *bilobatus*, S. N. (fig. 1 *b*) Sporocarps oval or reniform, three millimetres to six millimetres in diameter, each showing two rounded prominences at the ends, with a depression in the middle, and sometimes a raised neck or isthmus at one side connecting the prominences. Some of the specimens indicate that each prominence or tubercle contained several macrospores. At first sight it would be easy to mistake these bodies for valves of *Beyrichia*.

The geological relations of the beds containing these interesting remains are thus stated by Mr. Derby:*

* Proceedings of the American Philosophical Society, Feb. 21, 1879.

"The third or Curuà group consists almost exclusively of black and red shales, passing at times into shaly sandstone. These beds form low cliffs along the rivers Maecurù and Curuà for a considerable distance, lying almost horizontal, except where disturbed by eruptions of diorite. On the Trombetas the black shale forms two short cliffs on the river-bank and the red shale is badly exposed on a lake near by. At Ererè these rocks are exposed in the eastern part of the plain, and in the base of the serras, particularly that of Tajuri, the front of which is composed entirely of these shales. The black shale forms the lowest bed, the thickness of which, on the Curuà, is estimated by Mr. Smith at 300 feet. It is well laminated, almost slaty in structure, and in the lower part contains numerous large calcareous and arenaceous concretions. The first are bluish black in colour, have well-developed cone-in-cone structure, and emit, when struck with a hammer, a strong odour of petroleum."

"The reddish shale lies above the black, having, more or less, the same thickness. It is generally chocolate-coloured, mottled with spots of a darker hue, and banded, parallel with the stratification, with white, yellow or black. The rock consists of clay, mixed with a considerable proportion of fine-divided mica and sand, the last often forming independent layers a few inches thick. The only fossils found in these shales were fucoids, of the genus *Spirophyton*, and small fruit-like bodies, resembling very much a flattened currant, consisting, apparently, of a thin pellicle enclosing two to six small grains. The *Spirophyton* is apparently identical with one of those described by Prof. Hall, from the Hamilton group of New York. It occurs abundantly in all the localities, in both the black and red shale, near the junction of the two."

"On the Curuà and Maecurù the red shale, which is undoubtedly Devonian, is followed by beds of coarse sandstone which, according to Mr. Smith, are at least fifty feet thick on the Curuà. This is followed by fossiliferous carboniferous beds. The red shale is also overlaid by coarse sandstone, in the mountains of Ererè, but it is not certain that this sandstone is of the same formation as that of the Curuà."

"As regards the extension of the Devonian series, it has been recognized as far west as the river Uatumâ, a small river between the Trombetas and the Rio Negro. On the southern side

of the valley, there are, on the Tapajos, shales containing *Spirophyton* and calcareous concretions, which were referred provisionally to the Carboniferous by Prof. Hartt, but which seem to me to be Devonian, and I refer to the same age the black shale found by Sūr Penna on the Xingû."

I have not seen specimens of the black shales referred to in this description, but should think it likely that on careful examination they might be found to owe their carbonaceous or bituminous matter to the partial decay of *Sporangites*. They also deserve careful examination, with the view to the discovery of the vegetation appertaining to the sporocarps. The similarity of these Brazilian beds to those holding similar fossils in Ohio and Ontario is very striking.

There can be no question of the close resemblance of the Brazilian species of *Sporangites* with the spore-envelopes of modern Rhizocarps. Some individuals of the *S. Braziliensis* are scarcely distinguishable in form or contained macrospores from the sporocarps of *Salvinia natans* of the rivers of Europe (fig. 1 *d*). It is true that the analogy of *Salvinia* would lead us to expect other sacs containing microspores; but in ordinary circumstances the latter could not be preserved in a visible state, and in the Brazilian shales there are many specimens not showing macrospores, and which might have been filled with microspores which had been flattened into an undistinguishable mass.

If we compare the separate microspores of the Brazilian sporocarps, and especially those which are found detached from their envelopes, with *Sporangites Huronensis*, we see a remarkable similarity in size, form and texture, sufficient to justify us in supposing that the latter may be of the same nature with the former, but deprived of their outer cases either by dehiscence or by decay, and this is the view which I am now disposed to take of their nature, and which better accords with their wide distribution in aqueous deposits and with their accompaniments than any other supposition. I may add that Prof. Orton and Prof. Clarke, in letters to the author, refer to grouping of the little rounded bodies and traces of enveloping membrane. In this connection I would also mention the sacs containing rounded bodies known as *Parka*, and which have been met with in the Erian beds both in Scotland and in Gaspé, and have been supposed to be ova of crustaceans.

It is true that these are much larger than the sporocarps above referred to, but on examination of Gaspé specimens in my collection, I am disposed to suspect that they also may prove to be the fructification of Rhizocarps.

It remains to enquire, Are there any Erian plants known to us in their stems and foliage, to which such organs of fructification as those above described might have belonged?

A preliminary question would naturally be as to the vegetative organs of modern Rhizocarps. On reference to the descriptions, and to a somewhat extensive collection of specimens placed at my disposal by Mr. D. A. P. Watt, of Montreal, I find that these may be referred to three leading types. Some, like *Pilularia*, have simple linear leaves; others, like *Marsilea*, have leaves in verticils and cuneate in form; while others, like *Azolla* and *Salvinia*, have frondose leaves more or less pinnate in their arrangement. The first types present little that is characteristic, but there are in the Erian sandstones and shales great quantities of filamentous and linear objects which it has been impossible to refer to any genus, and which might have belonged to plants of the type of *Pilularia*.

It is possible also that such plants as *Psilophyton glabrum* and *Corduites angustifolia*, of which the fructification is quite unknown, may have been allied to Rhizocarps. With regard to the verticillate type, we are at once reminded of *Sphenophyllum*, which many palæo-botanists have referred to the *Marsiliaceæ*, though, like other palæozoic acrogens, it presents complexities not seen in its modern representatives. *S. primaevum* of Lesquereux is found in the Hudson River group, and my *S. antiquum* in the middle Erian. Besides these there are in the Silurian and Erian beds, plants with verticillate leaves which have been placed with the *Annulariæ*, but which may have differed from them in fructification. *Annularia laxa* of the Erian and *Protannularia Harknessii* of the Silurian may be given as examples. As to pinnate leaves, I have already referred to the remarkable plants of the genus *Ptilophyton*, found both in the Erian and Carboniferous, and which seem to have been aquatic in their habit like Rhizocarps. It is deserving of notice, also, that the two best known species of *Ptilophyton* (*P. princeps, and P. robustius*), while allied to lycopods by the structure of the stem and such rudimentary

foliage as they possess, are also allied, by the form of their fructification, to the Rhizocarps, and not to ferns, as some palæo-botanists have incorrectly supposed.*

I do not suppose that the facts above stated furnish any positive proof that the abundant *Sporangites* of the Erian period were the fructification of Rhizocarps, but they establish a certain probability of this, and invite to farther researches. If it should prove that these humble plants, now so insignificant, culminated in the palæozoic age, and occupied the extensive submerged flats of that period with an abundant vegetation, producing a great quantity of the bituminous matter found in the resulting beds, this early culmination of the Rhizocarps would be strictly in accordance with other facts in the development of the vegetable kingdom. We may even be permitted to speculate on the existence in the early palæozoic and eozoic ages of a rich Rhizocarpean vegetation, anticipating the great development of the acrogens in the later palæozoic.

I have not referred above to the well-known fact that in certain beds of coal and shale of the Carboniferous period there are multitudes of globular spore-cases or microspores not dissimilar from those above described. These may have been derived from plants of higher organization than the Rhizocarps, yet it is quite possible that this group of plants may have contributed to them. It is, however, only in the Erian that these *Sporangites* are so widely and abundantly distributed in aquatic beds, and that we have direct evidence as to their origin.

IV. On the Athabasca District of the Canadian North-West Territory. †

By the Rev. Émile Petitot.

Some nine years ago, I wrote a short paper on the Fur District of Athabasca, which was inserted in the Bulletin of the French Geographical Society, for July–September, 1875, and was also twice published separately. My subsequent journeys on the Upper Athabasca river, and a stay of some months on the lake of

* See Report on Erian Plants of Canada, 1882.

† From the Proceedings of the Royal Geographical Society for November, 1883.

the same name, have enabled me to collect fresh topographical, statistical, and historical material on this great district of the Canadian North-west; so that I have had to recast my former account in order to interpolate these recent acquisitions as well as my personal observations.

It will be needless to refer to the works of the first explorers of the region, such as Hearne, Mackenzie, Franklin, Back, Richardson, and others, or even to the more recent 'Wild North Land' of Captain Butler, as the commercial district of Athabasca, which takes its name from the river and lake, has undergone so many modifications during the last decade. In 1879, the Hudson's Bay Company joined a considerable portion of the Lesser Slave Lake and Mackenzie districts to the old Athabasca district, and its boundaries were defined by the dismembered and modified Mackenzie district on the north, the Churchill district on the east, the English River on the south, the Upper Saskatchewan on the south west, and British Columbia on the west.* From the Buffalo river, a southern affluent of the Great Slave Lake, the entire shore of that inland fresh-water sea up to and including the two Fonds-du-Lac on the east, belongs to this district; and Forts Resolution and Reliance, which are contained in it, are subordinate to Fort Chipewyan, the headquarters.

If a straight line be drawn from Fort Reliance (situated at the outlet of Artillery Lake, the mouth of the great river "Tpatchégé-tchôp," whose current is as perceptible across Slave Lake as that of the Slave River) to the 105th meridian, and the latter

* It should be observed that since M. Petitot's return to France, Athabasca has been re-defined as one of the four districts of the Prairie section of the North-West Territories, by order of the Privy Council of Canada dated the 8th May, 1883, in the following words:—"4th. Athabasca. The district of Athabasca, about 122,000 square miles in extent, to be bounded on the south by the district of Alberta; on the east by the line between the 10th and 11th ranges of Dominion Lands townships before mentioned [*i. e.*, the line dividing the 10th and 11th ranges of townships numbered from the fourth initial meridian of the Dominion Lands system of survey, or about 111° 30′ W. long.] until, in proceeding northward, that line intersects the Athabasca River; then by that river and the Athabasca Lake and Slave River to the intersection of the last with the northern boundary of the district, which is to be the 32nd correction line of the Dominion Lands township system, and is very nearly on the 60th parallel of north latitude; westward by the Province of British Columbia." This district is of larger area than Great Britain and Ireland.

followed to its intersection with the 61st parallel, the most easterly limit of the district is then defined. This imaginary line here meets a chain of crystalline rocks, belonging to the Laurentian system, which divides the basin of Hudson's Bay from that of the great interior lakes; and as this chain is the highest land in this region it serves as a natural boundary between the Athabasca district and the districts of the English River and Upper Saskatchewan. The Athabascan frontier leaves this chain a little to the east of La Biche (or Red-deer) Lake, and follows the 55th parallel to the Rocky Mountains, thus cutting the old district of the Lesser Slave Lake, in which Forts Assiniboine and Jasper are subordinate to Edmonton House, the headquarters of the Upper Saskatchewan. Then following northwards the great Cordillera, which is the natural western limit of the district, the frontier reaches beyond the Mountain River Portage, and comes again to the Great Slave Lake by a line passing between the nearly parallel courses of the Peace and Hay rivers.

The Athabasca district comprises two great rivers and two great fresh-water basins. The rivers are the Athabasca (better known locally by the Canadian name of La Biche, meaning Red-deer or Elk River) and the Peace River (also called "Des Castors" or Beaver River). The junction of these two forms the noble stream which, after connecting the Athabasca and Great Slave Lakes, takes the name of the Mackenzie. Its Indian names, which it preserves throughout its whole course, are "Dèsnézé" or Great River, and "Na-otcha-Kotchô" or River with giant banks. The lakes are the Athabasca (the "Lake of the Hills" of Hearne) and the Great Slave Lake (in Chipewyan, "Lake of the Crees").

To the chief topographical features of this district I propose to add my own observations on the nature of the soil and its products, statistics of the population, and some historical speculations, and I shall follow in these the natural direction of the waters, from south-west to north-east.

I.

The most southern source of the Athabasca river is in the Rocky Mountains in a little lake at the foot of Mount Brown, 16,000 feet high, not far from the sources of the Saskatchewan, Fraser, and Columbia rivers, and a little south of the Yellow

Head Pass. I do not know the exact length of the Athabasca from its source, but it cannot be less than 500 or 600 miles. There are 240 miles of its Slave River course from Fort Chipewyan to Fort Resolution on the Great Slave Lake, and the Mackenzie is reckoned as 1045 miles; this would give nearly 2000 miles for the entire river-system.

From its source to the confluence of the Clear-water ("Washé-Kamaw" in the Cree dialect, but more commonly called "Sipisis" or Little River) the general direction of the Athabasca is from south-west to north-east; from that point, after two very abrupt angles to the east and south-east, it goes almost straight north to the Athabasca Lake.

For my purpose, we are only interested in the river after its receiving the drainage of the Lesser Slave Lake, at which point it enters the district of Athabasca. Before that point it receives five small rivers, the Miette, Bonhomme, Baptiste, Macleod, and Pembina. This last name, or rather "Nipi-mina," is a Cree word for elk-berries (the fruit of a guelder rose, *Viburnum edule*, which grows there).

I should observe that the name Elk River, applied to the Athabasca, is not only unknown in the north-west, even to British settlers, but is incorrect, since it refers to the elk (moose) or "orignal" (*Alces americanus*), whilst the Athabasca bears the name of the "cerf bossu" of Canada (the wapiti),* called "biche" by the Canadians (the name of the female). The Crees call the wapiti "Wawaskisieu" and the Chipewyans "Thé-zil," or Reindeer of the Rocks, both tribes also applying these names to the great water-system of which I am treating, and which should therefore be called the Great Red-deer River.

A little below the outlet of the drainage of the Lesser Slave Lake, the Athabasca receives the waters of another river, also called La Biche, which drains the pretty lake of the same name. Still lower, on the right bank, are the confluences of the Crying River ("Kitou Sipi") and Wide River ("Kaministi Kwéya"), and on the left bank the Pelican River ("Tsatsakin Sipi"), and Lake Wabasca. The right bank also receives the House's River ("Waskaigan Sipi"); then, before reaching the turbulent

* It is a common error in North America to call the wapiti by the name of elk.

cascades and foaming sheets called the Great Rapid, the right bank is again broken by the "Miyotinaw," and the left by the "Nistaukam" (Mustuch or Bison River), whilst another (Red-deer or La Biche River), at least the sixth of the name in the district, also enters the Rapid on the left bank.

The large Clear-water river affluent is called "Otthap-dès," or River of the Groves, by the Chipewyans, and "Little Athabasca" by the Canadians. Inclosed between sandy banks 400 feet high, which it washes and eats away, revealing bare rocks of the most picturesque character conceivable, this fresh and limpid stream is literally buried under the natural bowers of vegetation following its shores and climbing the walls of its cañon. Nowhere have I seen more pleasing views, more crystal like yet impetuous waters more turbulent rapids and cascades, or more shady and varied woods. Its bed is covered with fresh-water mussels (*Unio*) which, however, the Indians do not eat, and its forests contain moose and bear. A pretty spring of sulphurous and saline waters rises from five different sources in the prairie near the river, and could be made the site of an excellent sanitary bathing establishment.

A trading-post called The Forks is situated at the junction of the Clear-water with the Athabasca. Beyond the Clear-water the latter receives on its right bank the Saline and Pierre-à-Calumets rivers, and on its left bank the Beaver, Red and Cypress rivers. The sandy banks of the Athabasca vary from 200 to 400 feet in elevation, and present many formations, all apparently belonging to the transition period.

Below the drainage of Lake La Biche and Wide River, on the left bank, a red-coloured exposure of the schistose and oblique stratifications which dip into the muddy current suggests the action of ancient subterranean fires, called "boucanes" by the Canadians. Here are found sulphates of iron and magnesia, nitrous deposits, and native carbonate of soda. In one place along the miry bank, a number of jets of hot steam find a vent through the mud, and make the waters of the river bubble. These traces of plutonic action are then transferred to the right bank, both above and below the confluence of the Clear-water, where there is a chain of volcanoes on a small scale, in the form of

little cones of whitened and scorified earth. Beyond these places, indications of active and extinct igneous action are only found on the right bank of the Athabasca and Mackenzie system, reappearing all along this immense fluvial artery with an intermittent activity and inaction difficult to explain. In some places these "boucanes," after having vented fire and smoke for decades, entirely disappear, only to show themselves without apparent cause elsewhere.

Traces of the subterranean bituminous veins that keep up these fires can be followed to the shores of the Arctic Ocean, in the cliffs of Franklin Bay and Cape Bathurst, where Sir John Richardson took them to be active volcanoes.

These "boucanes" are usually found on the line of imperfect coal, *i.e.*, of deposits of lignite incompletely carbonised, and consequently unfit for the forge or fuel. They are so along the Boucanes River, one of the affluents of the Peace River, as well as above Fort Norman on the Lower Mackenzie; but here there is no outer trace of coal or lignite, though it is probable that there are subterranean veins of those substances, and that the phenomena mentioned are owing to the protocarbonated hydrogen of the coal deposits. Nevertheless (although fire-damp explodes on contact with oxygen, as is often found at the beginning of winter in some of the lakes of the north-west), the capability of spontaneous illumination which Richardson attributes to the identical exhalations of Fort Norman, has not been found to exist in this gas. It is impossible to attribute to the Indians the extinction of the fires of bituminous schists in the Athabasca-Mackenzie system. Their ignition is intermittent, without apparent cause, and unstable. It is, moreover, accompanied by a strong smell of petroleum, whilst hydrogen is inodorous. But the carburets of hydrogen, of which petroleum is composed, do not make it, any more than they do fire-damp, spontaneously inflammable, even on contact with air,—in spite of received popular opinion. We must, therefore, consider them as one of the effects of igneous action, materially connected with the fire of the volcanoes; for the Boucanes occur under similar conditions to the vents of these subterranean fires, being found on the river banks, on intermediary strata inclosing schist, bitumen, lignites, thermal sulphurous or saline waters, rock-salt, &c.

I have observed a saline spring near the mouth of the Clear-water; a little below this point the Athabasca receives a saline feeder, which rises in a natural salt-spring of considerable size; and below Lake Athabasca, on the left bank, is a second saline feeder, rising in the Caribou Mountains, which contain vast deposits of rock-salt, and a cavern remarkable for its crystalline concretions.

Still further, between Forts Simpson and Norman, two other saline streams, unfit for drink, are fed by the mines of rock-salt contained in Clarke's Rock, a mountain of volcanic aspect. Lastly, there is a fifth saline river not far from the Arctic Ocean.

About 56° 30′ N. lat., the Athabasca meets Birch or Bark Mountain, a continuation of the heights forming Portage la Loche or Methy Portage (named after the loche or fresh-water cod-fish) and leaves its former course in order to open a way across the ravines of the mountain, thus making a right-angled elbow at the east. This wonderful cañon is called the Great Rapid. For some twenty-five or twenty-eight leagues it impedes and much endangers the navigation of the Athabasca. Besides the Great Rapid, properly so called, the traveller must pass as best he may the Brûlé, Noyé, Pas-de-bout, Croche (or Sinuous), Stony, Cascade, and Mountain Rapids. In short, the whole make one continuous rapid, twice as long as that of the Bear River, for the current sometimes reaches a rate of twelve to fifteen miles an hour.

There is nevertheless, strictly speaking, no cataract in the Athabasca canon, only a very strong declivity, in the form of a rapid flat sheet of water, obstructed by enormous boulders. At its commencement the river finds itself checked by the vast natural dam of Bark Mountain, the base of which is sandstone or madreporiferous limestone. The raging flood dashes against this obstacle, in which it has striven to batter a breach for centuries, washing away and carrying off the quartzose particles and exposing the madreporic conglomerate, shelly limestone, or bituminous sandstone forming the base of this vast deposit, and detaching and isolating a multitude of globular masses of solid or hollow sandstone contained in the quartzose sand, which now obstruct the bed of the river and are the cause of its foaming rapids. These concretions are found at every elevation of the cliffs, from the size of a coat-button to that of a Dutch fishing-vessel; they are of all degrees of

measurement and bulk, and of elegant or grotesque shapes, from buttons and turnips to the planet Saturn with its rings.

I have never seen in any geological text-book an explanation of the formation of these lenticular concretions, geodes, or pisolites, which I cannot believe to be merely concretions of sandstone rolled and rounded by the action of water. I am inclined to the opinion that they are masses thrown up in a globular form by some subterranean igneous force, and falling into the water holding much mud in solution, in which they have passed from a pasty condition to a solid consistency, crystallising as it were in it by the action of cold. I adopt this view, because these pisolites (whether geodes or not) are only met with in this district near rapids and waterfalls, in localities exhibiting numerous traces of subterranean fires formerly much more active and powerful than now; and because I have found some of these concretions composed of iron pyrites, crystallising from the centre outwards, and also others of bog iron. Whatever may be the method of formation of such singular freaks of nature, the Athabasca in eroding a tortuous and deep channel through the sandstone of Bark Mountain, finds its bed obstructed by these gigantic concretions, which are the sole cause of its rapids, and render its navigation so perilous as to be well nigh impossible. Besides this danger, great numbers of them are exposed on the sandy surface at all heights of the cliffs, forming immense caps constantly threatening the heads of the unsuspecting travellers beneath.

Remarkable vegetable fossils are often found in the sandstone of this part of the Athabasca, imbedded in the rock, but capable of detachment with the hammer. I have noticed whole trunks of *Cupressoxylon* (probably a *Sequoia*), characteristic of the tertiaries, and have sent specimens of it to Montreal and to Paris.

Near the Clear-water a pudding-stone begins to appear in horizontal layers from the level of the water, probably also reaching below it. This conglomerate is here overlaid by oblique stratifications of bituminous schist, which transude asphalt from top to bottom. The savannas and swamps covering the surface of these rocks conceal rich mines of bitumen under their thin coat of turf; and from Point Colbert to the Pierre-à-Calumets river they have given rise to the Chipewyan name of "Ellel Dèssé," or "River of the moving grounds."

The proximity of pisolites and considerable deposits of quartzose sand leads me to the belief that the bituminous matter exuding from the black cliffs of the Athabasca is *Pisasphaltum areniferum*, characteristic of the tertiaries. It flows in summer in wide sheets from the schistose flanks of the cliffs down into the river, mixing with the sands and solidifying so as to form a conglomerate, sometimes softened by the sun's rays and at others hard and brittle, of which fragments detached by the waters are carried down and deposited on the shores of the Athabasca-Mackenzie system, where they could be mistaken for nodules of basalt. They acquire an astonishing degree of hardness, and it is only by accident that their true origin is eventually discovered.

The bituminous schists are replaced at intervals by a shell-bearing limestone of dolomitic character, sometimes milky white. From this I have extracted various fossils, including *Terebratulæ*, very small Belemnites, *Atrypa reticularis*, *Cyrtina hamiltonesis* and *C. umbraculosa*. These limestone strata are undulating, and occur both above and below the water-level.

The shores of the Athabasca present an attractive sight. Far from injuring plant-life, the presence of naphtha and the subterranean fires seem to have imparted new vigour to it, so that the lofty banks have their steep slopes covered with vigorous and varied vegetation. Besides white pine, larch, aspen, and birch (which gives its name to the Bark Mountain), the forest trees here include, Virginian pine, cypress, Banks's pine, Weymouth pine, balsam-poplar, alder, and many kinds of willow.

Along its waters, discoloured by muddy matter and loaded with deposits to such an extent as to be prejudicial to fish-life, I have collected a large number of medicinal plants: *Geum strictum* and *rivale*, *Verbascum*, *Elæagnus argentea* (a very sweet-smelling shrub whose berries are a great delicacy to bears), *Lonicera parviflora*, *Cypripedium* with its large golden lips, saxifrages, *Polygala*, *Erythronium dens-canis*, and beautiful scarlet lilies like the Martagon, which would be an ornament to any garden. The Indians are very fond of the bulbs of this latter plant, which the Tinneys* call "Télé-nuié" (or Crane bread) and the Crees

* Also variously written as Tinneh, 'Tinnè, 'Dtinnè, Dinnè, Dinè, Dinneh, Dènè,' &c. (meaning "men" or "people")—the great northern or Athabascan family of Indians.

"Okitsanak." The eatable *Hedysarum* with blue flowers, and the poisonous one with yellow (known as the Travelling Vetch) are found there also. The male fern adorns the woods with its large fronds, and others, such as *Polypodium*, Capillary, and *Scolopendrium*, carpet the mossy rocks with their elegant plumes. But the most abundant plant all along the river is sarsaparilla. The Tinney of the Beaver tribe know this smilaceous plant as a febrifuge and sudorific, and collect its roots; but they are not aware of the anti-syphilitic properties of smilacine, a tannic base contained in it, and which I have more than once pointed out to them.

It is a curious fact that I have never heard a *Cicada* in the Northwest, though on two occasions (in 1876 and 1879) I satisfied myself of the occurrence of those insects at the junction of the Clear-water and the Athabasca, though I only found them on that spot.

The wapiti has become rather uncommon in the forests of the Athabasca, but the moose is frequently met with there. I have never travelled along this noble river (and I have done so six times) without seeing it, sometimes as many as three individuals together. The frugivorous black bear, lynx, beaver, and otter are common. On June 23rd, 1879, I met two Cree hunters who declared that since the spring (*i. e.*, in less than three months) they had between them killed along the river two hundred beavers, twenty-five moose, twenty bears and five wapiti; and I may add that from experience of the Redskins I know they are more given to diminish than to exaggerate the results of their hunting. This shows that life could still be maintained on the river if there existed inhabitants able to hunt and provision the trading-posts. But from the drainage of the Lesser Slave Lake to Lake Athabasca there are but thirty-one Crees and twenty-two Chipewyans, women and children all told.

The original mouth of the Athabasca is now distant a good day's navigation from the lake. It is shown by the simultaneous receding of both the high strands forming the bed of the river, which from this point keep widening away from each other until they disappear in the interior. A flat uniform plain follows, composed of accumulations of soil, with no admixture of rock, and covered by dense forest growth. The river has thus actually

filled up its own ancient estuary with the material it has carried along, for no other in the world is more loaded with muddy deposits, vegetable detritus, and floating trees.

Almost immediately after this the river divides into two arms, of which only the right-hand one retains the name of Athabasca, the left taking that of Embarras, because of the frequent bars made across it by the timber borne on its waters. Further on, the Athabasca channel is subdivided into three other branches, of which the central was the principal channel in 1879, whilst the left one, known as the Brochets (or Pike) River, rejoined the Embarras branch. But all these channels are interconnected by a multitude of creeks, not reckoned by the natives, as they are only navigable by bark canoes.

Some maps make the river Athabasca communicate with Lake Mamawi (or Mamawa), which is also represented as an expansion of one of the mouths of the Peace River; but this is a double error. Lake Mamawi (meaning in Cree, Reunion or Assemblage) receives its waters from Clear Lake, with which it communicates by a very short arm called the Hay River ("Klopè-djiéthé"); and Clear Lake itself is fed from Bark Mountain, having no connection with the Peace River. But before entering Mamawi, the waters of Clear Lake bifurcate, the left channel discharging under the name of the "Des Enfants" or Children River, into the most eastern mouth of the Peace River, called "Aux Œufs" or Egg River, which flows into Lake Athabasca.

The waters of Mamawi are also drained into the latter basin by four channels, of which the right-hand one passes direct into it, the other three eventually uniting and emptying into the eastern mouth of the Peace River, which, before reaching Lake Athabasca, sends out an arm towards Lake Mamawi. This quadruple channel bears the name of the Four Forks, and is the cause of the Cree name for Mamawi. Very curious tidal fluctuations result from this arrangement. In ordinary weather, with things in their normal condition, the above description is correct. But as the level of Lake Athabasca is materially heightened at the period of flood, the waters of its basin, or more correctly the currents of the Athabasca which cross it, flow back in the direction of the Four Forks, reaching Lake Mamawi and even Clear Lake itself, so that they connect the first with the eastern or Embarras chan-

nel of the Athabasca, and inundate all the prairies between the different mouths of that great river, forcing the Egg River to flow back to the main branch of the Peace River which joins the Great Slave River.

Such was the condition of the estuary of the Athabasca and its mouths in Franklin's time (and also in 1876); and if there are errors in the maps of that time, they are either owing to incorrect information or to misunderstanding; for I can scarcely believe that the first explorers were able to visit all of these localities, considering the short time they spent in the country.

The vast marshy savanna of this delta—an ocean of tall grass, mare's-tail, *Cyperus*, reeds, and willows, intersected by numberless miry creeks always covered with water-fowl—is well called in Cree "The Herbaceous Network," which is practically the meaning of Athabasca, Ayabasca, Arabasca, and Wabasca, in the Algonquin dialects,—a name applied to the entire lake and also to the river by Europeans.

There are often not more than two or three feet of water in these creeks of the Athabasca; but sometimes the whole estuary is submerged and becomes part of the lake, still bearing on its muddy surface a flotilla of huge trees which have got locked together and materially heightened its level. I saw such a state of things in 1871 and 1876; but how different was the estuary three years after! At that time, the channels of the Athabasca were almost dry; the main current had left the central one and gone wholly to the east, and the savanna of the estuary, elevated many feet above it, was changed into the immense and perfectly firm prairie, covered with young willow copses and dotted with water-holes.* But the most remarkable thing was that the estuary of the Athabasca had entirely left this high and dry prairie, and betaken itself to a point between its old mouth and that of the Peace River, into the Rocky (or Stony) River, the drainer of the great lake. The expanse of waters between these two points had therefore vanished, and the once great bay of Lake Athabasca, so picturesque with its chains of granitic pine-clad isles, like a fleet of war-ships preparing for nautical evolutions, had wholly disappeared. Perhaps I should more correctly say that this basin of five to six leagues still existed with its rocky rim, but instead of

* See Macoun, in Rep. Geol. Survey of Canada, 1875-76, p. 91.

water it contained grass; instead of resembling a vast turquoise set in a jasper border, it seemed an emerald, silver-veined. This part of the lake was also transformed into a prairie, from Bustard Island to the Rocky River, and its former islands, now surrounded by fertile land, only lacking the plough to produce splendid crops, were mere isolated elevations—landmarks destined in future ages to show that once the white-fish, the carp, and the pike disported in places destined, I hope, to be improved ere long by high cultivation.

This condition of the waters endured till I left the North-west; for in 1881 Mr. R. McFarlane wrote to me that this drying-up had proved a severe calamity to the Redskins of the lake, who had hitherto derived plentiful supplies of food from the well-known fisheries of the Four Forks and Bustard Island, now of course entirely destroyed.

It seems that the four mouths of the Athabasca, the embouchure of Lake Mamawi, and the eastern (or Egg River) channel of the Peace River, retained their respective currents beneath the waters of the lake, before filling it up; and when the level of the lake had become considerably heightened by their numerous interconnections, their beds remained like so many narrow rivers, which now run through the dried-up mud, far from the ancient isles, to reunite in the great outlet of the Rocky River.

Unless some extraordinary flood remodifies this newly formed estuary, the Athabasca district will thus have gained an immense space of land, excellent for cultivation, and not requiring artificial fertilisation for very many years; and it should be noted that the climate of the lake is far from being an obstacle to the ripening of cereals and vegetables, for at the Philadelphia Centennial Exhibition in 1876, the Catholic Mission near Fort Chipewyan obtained a silver medal and honourable mention for cereals of the first quality and remarkable size. In fact, the chief want of the lake-district as regards colonization is vegetable mould. With the exception of the estuary above mentioned, and of the still more extensive and no less extraordinary one of the Peace River, only rocks are found in it; and it may be said with truth that the entire north from the Slave Lake and River to Hudson's Bay is only a gigantic bed of crystalline rocks, where the planetary nucleus is exposed under the form of various granites, feldspar,

syenite, porphyry, serpentine, &c. Vegetation is only to be seen in the inequalities of the stony surface or depressions in these products of fusion, where the action of water has not entirely cleared away their sandy surface, or where it has deposited a slight layer of sedimentary earth, as at the Chipewyan Mission. Conifers, black alder, heather, *Cistus*, *Absinthium*, and some other aromatic plants root in the meagre soil, and diminish the melancholy aspect of this vast exposed portion of the frame of nature.

I firmly believe that all the land reclaimed from the Peace and Athabasca rivers is of the best quality, if the present conditions are maintained. But there is always the fear of some exceptional rise in the waters causing a sudden flood, of such a nature that the vast plains recently uncovered might be once more overrun by devastating currents washing away their soil and entirely re-modifying their surface.

I have travelled over the whole of the estuary of the Peace River,* above referred to, and found it no less curious than that of the Athabasca. As before mentioned, its first or most eastern channel enters Lake Athabasca at the Four Forks, under the name of Egg River; and the maps are quite wrong in representing the Clear Lake River as another mouth of the Peace River. But between the Egg River and the Canard or Duck Portage, where there are unmistakable traces of an old western channel, this river has four other openings into the Slave River, without counting six creeks originating in the same number of lakes formed by the overflow of the Peace River, but with no currents of their own, directly its waters retire. Between the two last-named points, therefore there is an immense plain, comparable in fertility with the delta of the Camargue in Provence, intersected by rivulets and dotted with lakes and ponds. Forest-trees have sprung up in it, and pine-crowned hillocks rising in a hundred different places show the position of former islands. Crops of the highest quality could be raised on this gigantic and well-watered delta, which contains prodigious quantities of timber deposited by the waters during past ages. I am firmly of opinion that the colonization and cultivation of this portion of the Athabasca district deserve serious attention, and I have therefore done my best to prepare a

* On the Peace River District, see also Dawson, in Rep. Geol. Survey Canada, 1879-80, (B) p. 66 *et seq.*

map of those two great estuaries as accurately as possible, preserving the local names of the lakes and water-ways. This map is, indeed, the chief result of my labors.

Besides these vast deltas there are other lands, on the left bank of the Slave River, perfectly fit for cultivation; this is indeed proved by the old settlement of the Beaulieu family on the banks of the Salt River; but the settlers there would have to struggle against inextricable forests, and an entire want of roads or other communications, without mentioning other serious inconveniences.

But there is in the Athabasca district a belt not overrun by forest, and which has nothing to fear from periodical inundations; where timber only grows sufficiently for the needs of colonists, and is rarely a mechanical obstacle; well covered with undergrowth and grass, capable of cultivation, crossed by a waggon-track, watered by streams, stocked with fish-bearing lakes, and offering every facility and advantage for the construction of a railroad. I refer to the zone of natural prairie along the Rocky Mountains, from the mountains of the Upper Saskatchewan to the banks of the Hay River, one of the feeders of the Great Slave Lake. I have been told by very many persons who have travelled over the Great Prairie, by which name this fertile belt is known, that it comprises every condition requisite for settlement, as well as being rich in lumber requisites and minerals of all kinds. Sulphur, bitumen, and coal crop up in many places, with rock-salt, iron, native copper, and even gold (according to report). Against these advantages, must be set the fact that the means of subsistence have become more and more rare, from the rapid diminution and imminent extinction of the animals which supplied the daily food of the Indians, such as the moose, caribou, wapiti, bison of the woods (a distinct species from the musk-ox and prairie bison), beaver, porcupine, &c. The musk-rat alone seems not to have failed as yet, and continues, as before, to swarm on the lakes, ponds, and smallest streams. I can only regret that I have no personal knowledge of this fertile region.

II.

Lake Athabasca is the smallest of the fresh-water seas which stretch like a chain from the Gulf of St. Lawrence to the Arctic Ocean, east of the Mississippi, the Red River of the North, and the Athabasca-Mackenzie system.

It is 230 miles long by twenty miles broad, and about 600 feet above the level of the Arctic Ocean, according to the observations of General Sir J. H. Lefroy. The position of Fort Chipewyan, the headquarters of the district, is 58° 43′ N. lat., and 111° 18′ 32″ W. long.; that of Fort Fond-du-Lac is 59° 20′ N. lat. and 107° 25′ W. long.

Like a number of other lakes in this region, it is a crystal sheet of water lying in a deep bed, granitic at the north end, and with sandy and muddy deposits at the south. Three of its sides are granite, and a great number of granite islands thickly set with pines dot its surface. But there are no mountains there, and Hearne, the first explorer in 1771, would have been more correct in naming it Lake of the Isles than Lake of the Hills, as the abundance of islands strikes the traveller at the first glance.

I have already explained the Cree meaning of Athabasca. The present inhabitants, the Chipewyan Tinneys, call it "Yétapè-t'ué" (Lake Superior), or more habitually "Kkpay-t'èlè-kkè," or Willow bed, alluding, doubtless, to the deltas. This was also the name of an old trading-fort at the mouth of the Athabasca river, where willows were the dominant feature of the vegetation, only conifers and aspens being visible elsewhere.

The nature of the soil of the lake is therefore identical with that of the great lakes tributary to Hudson's Bay, such as Lakes Wollaston, Caribou, Beaver, and Bear, the Lake of the Woods, and Lake Winnipeg, and of those which drain to the Atlantic, as the Canadian lakes proper.

The fishes of the lake are *Coregonus lucidus* or white-fish, salmon-trout (which there, as in more northern waters, reaches thirty-five lbs. and over), Canadian trout, *Catastomus reticulatus*, maskinongé (*Esox estor*), grey and red sucking-carps, sandre (*Lucioperca Americana*, called doré by the Canadians), the golden-eyed lakêche, lamprey, methy (*Lota maculosa*), &c. I only refer here to the larger species, for the very sufficient reason that the smaller ones are entirely unknown.

The north of the lake, which is wholly sterile and rocky, only affords support for caribou, which find a palatable food in various lichens growing there. The animals and plants of the forests and prairies to the south have already been referred to.

It is obviously impossible that very exact cartographic representations should exist of so vast a lake, which has only once or twice been visited by scientific observers, and then only partially, having never been explored as a whole. I have therefore here also to make some alterations in the maps now current.

The lake receives eleven watercourses, of which eight (the Peace, Mamawi, Athabasca, Little Fork, William's, Unknown, Beaver, and Other-side rivers) are on its south. The Grease and Carp rivers enter into it from the Barren Ground; and the Great Fond-du-Lac river flows in on the east. The latter drains into the lake the waters of the Great Black Lake and the Lake of the Isles, a basin dotted with granitic blocks and fed by two streams which are practically a chain of small lakes. The most southerly of these rises at the foot of Beast's Mountain, not far from Wollaston or Great Hatchet Lake; the northern one rises near Lake Caribou, but without having any kind of communication with it.

It was doubtless the proximity of these two great lakes to the most eastern sources of Lake Athabasca that caused Hearne to believe that Lake Wollaston was connected with Hudson's Bay by the Churchill river, and with the Arctic Ocean by Lake Athabasca. Nothing, however, could be more incorrect. The most northern source of Lake Wollaston is the glacial river springing from the elongated granitic water-parting before mentioned. This lake drains into Lake Caribou by the Canoe River, a simple connecting arm, and communicates with the Churchill River by the Deer River. But there is absolutely no communication between the lakes occupying the two slopes of the water-parting.

I have therefore corrected four geographical mistakes about these Canadian lakes, to which various drainages have hitherto been attributed. The first mistake refers to Lake La Ronge, which empties into the Churchill, and which was also said to open into the Beaver River; but I showed in 1873 that the Beaver receives the La Plonge River, which rises near Lake La Ronge, though not taking the actual waters of the latter lake. The second concerns Lakes Wollaston and Athabasca, as above stated.

The third refers to the Great Bear Lake, to which Sir John Richardson attributed three outlets, viz., the Bear Lake River and the Hareskin River, entering the Mackenzie, and the Beghula River, entering the Arctic Ocean. In ascending these three rivers to their respective sources, I proved in 1869–70 that the Bear Lake has only one outlet, viz., the river of the same name; that the Hareskin River flows out of the Wind Lake near Smith Bay in Bear Lake; and that the Anderson (the "Beghula" of Richardson) rises in a little lake at the foot of Mount "Ti-dépay" quite to the north of and some distance from Bear Lake. Lastly, the fourth error is regarding the famous great lake of the Eskimo, to which various openings into the Arctic Ocean were attributed, besides one outlet in the mouths of the Mackenzie and another in the Anderson River. It is now known that this lake (the size of which has been considerably diminished) has but one outlet, the river "Natowdja," a direct tributary of the Arctic Ocean.

I also made, in 1879, a complete survey of the course of the Slave River from the great lake of the same name to that of Athabasca, in order to complete my former work on the Mackenzie; and it is remarkable that, although I had no map to refer to, and no other instrument than a compass, the result agreed almost exactly with Franklin's route-map of 1820, except as regards some islands, which either escaped his observation or have been exposed since his journey, some winter-portages that he never crossed, and a few bends in the river which he probably passed at night-time.

Above the rapids formed by the Caribou range, where that range leaves the left bank and turns off towards the east, along the course of the great Des Seins River, or "Thou-bau-dessé,"* the Slave River crosses a flat plain covered with inextricable forests, apparently reclaimed by degrees by the sedimentary deposits of its muddy waters. This river has no sandy shores. Its muddy banks are constantly washed off on one side to be deposited on the other. At times they give way, and the current,

* This river, a southern affluent of the Great Slave Lake, is apparently represented on M. Petitot's map by the "T'al'tsan-Dessé" or Yellow Knives River. The name used in the above text seems to agree with the "Thuwu-desseh" of the map of Back's "Narrative" (1836), which enters the Slave Lake to the east of the mouth of the Slave River.

precipitated with violence into the forests, opens fresh channels, whilst the old ones, obstructed by the mire and sand brought down, are filled up and transformed into a marshy savanna. The Duck Portage was formed in this way. Entering it from the north (the direction facing the current), the idea is suggested that it is a channel of the river or one of its affluents; but the traveller soon finds himself in an immense dried-up marsh, quite level, and entirely composed of black viscous mud, cracked by desiccation and covered with timber formerly deposited by the waters. Its Chipewyan name, "Tédh dédh-héli t'ué" (Float-wood Lake) points to its origin. There is however, no trace of any lake; but a chain of wooded and elevated isles shows that this is the ancient bed of the Slave River, which, after filling in with muddy deposits, has been obstructed in its course by imbedded timber and forced to break a passage to the right by an abrupt eastern elbow. I think this alteration of course has been effected recently. It may perhaps be the outlet which I saw in course of formation in 1862, though I had then no opportunity of accurately fixing its position.

During extraordinary floods the surplus waters of the Slave River spread over this great marsh and scour the Duck Portage; but at an epoch before the formation of the present bed, when the Duck Portage was the ordinary channel, the overflow passed to the left by another natural channel, now dry. This shows a gradual tendency of the Slave River towards the east in this district. The conditions above referred to as existing at the mouth of the Athabasca, are also shown at the mouth of this river, for the current has so clogged its bed and filled up its estuary as to be compelled to divide and make its way across the sedimentary deposits of its delta, which it cuts up into a great number of mud islands.

The first and oldest of its branches contained large and lofty islands, identical as to soil with the mainland, and wooded, like it, with white pines, *Populus balsamifera*, aspens, and birches, whose venerable trunks show an existence of at least six or eight centuries. If a line be drawn on the right from this point to the mouth of the Des Seins River, and on the left to that of the Oxen River, a triangle or delta will be described wholly occupied by the ancient and recent mouths of the river. The latter, after divid-

ing into three channels, is subdivided into two great median arms, of which the eastern one is called Jean's River, a corruption of the Chipewyan name "Dzan-des-tché," literally Mud-river end, or Muddy mouth. Up to this point standing trees are found in the delta, but they are no longer coniferous, thus showing that the islands are of later formation. As the channels subdivide vegetation decreases with them; aspens, poplars, and alders have disappeared, and only small willows, six to eight feet high, are found. Still lower down, nothing is found but reeds, bulrushes and at last only mare's-tail (*Equisetum*), an exclusively aquatic growth, entirely covered during floods.

Such are the products of the last sedimentary formations, which are not yet consolidated. Between them and the lake extends a moving bog, fluctuating with the waters, which cover it for a few inches. Any unfortunate boat running into this mud will infallibly become as firmly imbedded as the innumerable tree-trunks whose roots are horizontally exposed above its surface. Some years hence these unsolid and unfathomable banks will, become firm, and, aided by the accumulations and drying effects of frosts in winter, will form new islands, more and more encroaching on the Slave Lake.

During the 240 miles of the course of the Slave River, it only receives two affluents, one on each bank, viz., the Dogs and the Salt rivers, the first of which is above and the second below the Rapids, interrupting its navigation.

The maps of Lake Athabasca give indeed its southern affluents, but two of these, the Unknown and Beaver rivers, are not represented to be of large dimensions, nor are the lakes from which they spring shown as being within so comparatively short a distance of the lacustrine enlargement of the Churchill known as Lake Lacrosse, that passage from the latter to the tributaries of Lake Athabasca could be made by the head-waters of the Caribou river. I have thought it right to rename these two great rivers and the lakes from which they spring after Messrs. C. P. Gaudet and R. McFarlane, as a mark of my respect and gratitude.

III.

The first person entitled to honour as the explorer of Lake Athabasca, was Samuel Hearne. He discovered it in 1771, and named it "Lake of the Hills." Seven years afterwards, the

North-west Company sent hither a Canadian, Joseph Frobisher, who founded the first trading-post. The Hudson's Bay Company soon followed the example of its rival, so that here, as in many other places, these two commercial bodies found themselves in competition at an early date. Nevertheless, the discoveries of Hearne, of Peter Pond in 1779, and even of Sir Alexander Mackenzie in 1789, however authentic and scientific, were apparently anticipated by the far-reaching tracks of the *coureurs de bois;* for when Pond reached the Great Slave Lake, the half-breed Canadian family of Beaulieu had already settled on the Salt River—one of them, named Jacques, indeed acted as interpreter for this trading-officer, just as, at a later date, his nephew François was Sir John Franklin's hunter and interpreter.

In 1820, and again in 1829, Sir John Franklin, accompanied by Lieutenant Back and Dr. Richardson, visited Athabasca on their way to the Arctic Ocean, when commencing their explorations for the famous North-West passage. The portrait drawn by these travellers of the Chipewyan Tinneys (whom they also call, though wrongly, Athabascans) is anything but a flattering one, and shows the recent change for the better in the character and disposition of these Indians. I can myself speak of as great an alteration in the Beaver Indians, who are now as gentle and inoffensive as they were thievish, shifty, and faithless twenty-five years ago. This is the natural effect of the commercial relations and religious habits acquired since that date by those child-like tribes.

The Chipewyans, without being as timid as their northern brethren, who deserved the uncomplimentary epithet of "Slaves" bestowed on them by the first explorers, are now a gentle, peaceful, and honest people, comparatively chaste and religious, though they may perhaps be accused of being a little too morose in disposition and fond of solitude. The Catholic Missionaries first visited them in 1847, and two years later settled among them. In 1866 or 1868, if I remember rightly, a clergyman of the church of England was domiciled at Fort Chipewyan; and lastly, in 1875, the Montreal sisters of charity founded a school with an orphanage and hospital there. This fort has for some years been the seat of an Anglican bishop.

From the time of the historian Charlevoix a vague acquaint-

ance with Lake Athabasca must have existed in Canada, for he speaks of the Dog-rib Indians and the "Savanois" (now called "Mashkégous" [Maskigos] or swamp-dwellers), the former of whom lived at the north-east of the lake, while the hunting-grounds of the latter were to the east and south-east.

At this date, the Ayis-iyiniwok or Iyiniwok (Men), called by Duponceau "Killistini," by the Ojibbeways "Kinistinuwok," and by the French "Cristineaux" (also called "Klistinos" and "Knistineaux"), from which have finally been derived the names Cris, Crees, Kree, and Krî, lived on the banks of the Beaver-Churchill river, which they called Great Water (Missi-Nipi), as well as on the shores of Cross-isle Lake, Moor-hen Lake, Cold Lake, &c. In short, they occupied the country between the Savanois Indians on the east and the Grandspagnes (also called Prairie-Crees), on the west. The Chipewyans at that time lived along the course of the Peace River, after crossing the Rocky Mountains, not having yet ventured down into the country now occupied by them between the Great Slave Lake and Frog Portage on the English River. It was in fact their primitive home in the Rocky Mountains that originated the Canadian name "Montagnais" or Highlanders for these Tinneys, who now live in a flat country.

Lake Athabasca, the Slave River, and the shores of the Great Slave Lake were the exclusive territory of another tribe of Tinneys, to whom the epithet of Slaves was given, from their natural timidity and cowardice. They themselves recognized two divisions, people living among the hares (or northern Tinneys), and among the rabbits (meaning the Chipewyans). The latter name is applied by the Crees to the entire Tinney nation, and means "Tailed men," *i.e.*, men clothed in tailed skins. This arose from the fact that all the Tinneys, like the modern Dindjiés of Alaska, used to wear a fringed robe of moose or reindeer skin, ending in a long point in front and behind.

The Indians using the Algonquin tongue, such as the Crees, Savanois, Grandspagnes, and Ojibbeways, carried on a pitiless war against the Athabascan Tinneys or Slaves, who from natural timidity gave up their territory to their enemies, and fell back on the Great Slave Lake, pursued by the Crees, who made a great slaughter among them. Various islands and archipelagos retain

the name and the memory of these dreaded Ennas (strangers, enemies), including Dead Men's Isle, which keeps alive to this day the recollection of the defeat of the Katchô-Ottiné, subsequently called Slaves. From that time, this portion of the Tinney family never ventured south, but remained in the cold lands and swampy forests of the north, where they became split up and settled under the names of Dog-ribs, Hareskins, Highlanders, Slaves, &c. Their different tribal dialects vary but slightly *inter se*, differing much more widely from the Chipewyan.

The Kilistino or Crees, established on Lake Athabasca and its tributaries and discharges, found themselves exposed to the attacks of the Chipewyan Tinneys arriving from the west by the Peace River (called Amisko-Sipi or Beaver River by the Crees), thus proving that the Tinney family, or at least its northern tribes, are of later origin on the American continent than the Killini or Hillini Lléni. But, being as brave as, if not braver than, the invaders, they offered such a resistance that prisoners and slaves were made on both sides. Meanwhile the English appeared in Hudson's Bay at the mouth of the Missi-Nipi (called English River from them), and founded a factory there named Churchill, after the then prime minister of England. This became the medium of commerce between the coast Eskimo, the Savanois, and the Crees of the interior.

Before the Hudson's Bay Company sent Hearne to explore the interior, a Chipewyan woman named Tha-narelther (Falling Sable) was carried off by a Savanois war-party, and taken in captivity to the shore-region of Hudson's Bay. She saw with astonishment in the tents of her captors domestic utensils and arms entirely new to her, and as she at first believed them to be of native manufacture she admired the intellectual superiority of the Killini, and determined to remain with a people so superior to herself in intelligence and cleverness. But she did not live among them long before detecting from their ways and ceaseless wanderings that they obtained these things from strangers, in exchange for peltry and provisions. This traffic puzzled the captive, but, as she imagined that the original possessors of the riches bestowed upon the Savanois must be their relations or allies, she never thought of taking refuge with them and begging their protection.

Only after some years of harsh captivity, did she discover that the "Agayasieu" (the Cree name for the English), who supplied the Crees and Savanois, belonged to an entirely strange race, good-natured and generous, friendly with all the aborigines, and coming from the far east to trade with them. Her mind was then soon made up. She succeeded in reaching Fort Churchill alone, and as she had learned enough of the Algonquin dialect to make herself understood by the interpreters of the fort, she was enabled to let the Hudson's Bay Company's officers know that she belonged to the great nation of "Men" (Tinneys), living far off in the west, and professing honesty and fair behavior like the English. She expressed her determination of returning to her own people and begged for assistance on the way home, promising to establish friendly relations between her countrymen and the officers of the company, who, glad of the opportunity of extending the sphere of their commercial transactions, gave her a sledge and dogs, with various presents, and a safe conduct through the land of the Killini. Attracted by these presents, the Chipewyans at once undertook the long voyage from the Peace River to the mouth of the Churchill, calling the fort "Thé-yé" (stone house), and its inhabitants "Thé-yé Ottiné" (men of the stone house), a name by which the English are still known among the Tinneys.

These relations continued to the time when Joseph Frobisher established Fort Chipewyan, on the shores of Lake Athabasca, in 1778, for the North-west Company, at which date there were as many as 1200 Redskins settled on the Lake. But the white man brought with him the horrible disease of small-pox, till then unknown to the Americans, which made great ravages among the Tinneys, and more than decimated the Crees, driven to the southern part of the lake by the warlike attitude of the Chipewyans. Influenza, an epidemic catarrhal affection, attacking the tribes at regular intervals of about seven years, completed the work of the small-pox. Reduced to a very small number, the Crees ceased all hostile action against the Chipewyans, who had become their superiors, both in number and in strength; so that the possession of the lake, and indeed of the territory of Athabasca, remained with the Tinneys, who permitted a few Crees and Savanois to remain among them.

From Athabasca the Chipewyans spread north by degrees towards the shores of the Great Slave Lake, and east and north-east towards Hudson's Bay, where, having met with vast herds of wild reindeer, they settled on the Barren Grounds, living from that time in common under the names of Yellow-knives ("T'altsan Ottiné"), and Caribou-eaters ("Ethen eldéli"). Such of these as remained attached to the Churchill traders took the name of the latter, and are still known to their western fellow-tribesmen as "Thé-yé Ottiné." Finally, many of them even ventured south to Lake La Biche, Cold Lake, Lake La Ronge, Cross Island, Heart Island, &c., where they bear the name of "Thi-lan Ottiné" (Men of the end of the head).

When leaving the fertile plain watered by the Peace River and its affluents, the Chipewyan Tinneys were hard pressed by a tribe still more warlike than themselves, namely the Sécanais or "Thé-kké Ottiné" (Men who live on the mountains), who in their turn had come from the western slope of the Rockies, where they left tribes identical with themselves as to language and customs.

As to the Beaver Tinneys, they crossed the mountains to the south and reached the plains of the Saskatchewan, where still lives a remnant of this people, the Sarcis (in Cree "Sarséwi") whose Black-foot name means bad (from "Sa-arsey," not good).

Hearne permitted the association of some Chipewyans on his expedition to the Copper-mine River, a tributary of the Arctic Ocean, with a result that is well known, as is also the massacre committed by his followers among the Eskimo.

The Hudson's Bay Company was not long in founding a trading-post on Lake Athabasca, establishing one under the name of Wedderburne on an islet near Fort Chipewyan. This remained till 1821, when the rival companies united their interests and put an end to their regrettable hostilities.

Commerce and religion have materially civilized the manners and character of the Cree, Chipewyan, and Beaver Indians inhabiting the Athabasca district. They are at present quiet, peaceable, inoffensive, and friendly to the white man, but very much diminished in numbers, the failure of animal life, and the extraordinary decrease for many years in the waters of the rivers and lakes, which has destroyed the fish to an immense extent, and driven

away wild fowl, having caused such a famine that many died of hunger and misery between 1879 and 1881. There were 900 Chipewyans and 300 Crees at Fort Chipewyan in 1862, but in 1879 I could only find 537 Chipewyans and 86 Crees, even including those living on the river Athabasca. Now there is but one single family of Crees at the lake, and the remnants of the tribe have gone away to join their fellows of the Peace River.

The same fate has befallen the Chipewyans. In their total of 500 must be reckoned those of Fort Smith, at the foot of the rapids of the Slave River, as well as those of Salt River, and many families of the Great Slave Lake and Ox River.

In short, the Athabasca district, comprising the Peace River and parts of both the Lesser and Great Slave Lakes, now contain no more than 2268 souls, including 150 half-castes and fifty-seven white men of various origin—English, Scotch, Irish, and French-Canadians.

The following are the exact statistics in 1879, for which I am indebted to Mr. R. McFarlane, the chief of the district:—

Forts.	Tinney	Crees.	Half Castes.	Whites
Chipewyan, Smith, and Small Red River together	537	86	50	28
Fond-du-Lac	318	...	15	2
Resolution (Slave Lake)	300	...	25	15
Vermillion (Peace River)	234	6	15	2
MacMurray (Clear-Water River)	31	22	10	4
Dunvegan (Peace River) and Battle, together	195	137	20	6
St. John or D'Epinette (Peace River) and Slave Lake, together	195	...	15	
	1810	251	150	57

Grand total of the Athabasca district, 2268

The following statistics of the whole Athabasca and Mackenzie Redskin population (including women and children), were collected with great care by myself in various localities in which I have visited or stayed in at different times. I have before me synoptical tables by tribes and families, including even the names of the individuals.

Great Slave Lake.

Fort Resolution, 1863—64 ...	Chippewyans 245		
	Yellow Knives 332		
			577
Fort Rae, 1864	Dog Ribs		788

Mackenzie.

Providence, 1871	Slaves, or Etcha-ottiné...		300
Black Lake River, 1878	Etcha-ottiné		115
Hay River, 1874	" "		100
Fort Simpson, 1873	" "		300
Forts Norman and Franklin (Bear Lake), 1869, together...	Slaves or Etcha-ottiné	97	
	Dog Ribs	47	
	Mountain Indians ...	43	
	Hareskins	85	
			272
Fort Good Hope, 1867	Hareskins		422
Fort Macpherson (Peel River), 1866 including La Pierre's House ...	Dindjié or Loucheaux, Quarrelers, Kutchin ...		290
	Eskimo of the Anderson	250	
	" " Mackenzie	300	
			550
Forts Liard and Nelson, Liard River	(Not collected by myself) Slaves		500
	Population of the Mackenzie		4214

Athabaska.

Forts Chipewyan and Smith, 1879	Chipewyans... ...	537	
	Crees	86	
			623
Fond-du-Lac, 1879	Caribou eaters		318
Vermillion, Peace River, 1879 ...	Beavers	234	
	Crees	6	
			240
Fort MacMurray, Athabaska River, 1879	Chipewyans ...	81	
	Crees	22	
			53
Fort Dovegan, Peace River, 1879	Beavers and Sécanais	195	
	Crees	137	
			332
Fort St. John, Peace River, 1879 Lesser Slave River	Sécanais		195
	Population of the Athabaska		1761
	Maximum total*		5975

* These figures may be compared with similar but less detailed statistics collected by Captain (now Sir Henry) Lefroy in 1844, and published in the Proceedings of the Canadian Institute, 1853. They were also based on the books of the Hudson's Bay Company's trading posts and the personal knowledge of its officers. The enumeration of the Tinney under various subdivisions comes to 1592 men, estimated to represent 7575 souls. To these were added, at Fort Chipewyan, Lesser Slave Lake, and Isle à la Cross, 209 families of the Crees, estimated at 1081 souls. The Indians have apparently, therefore, decreased in numbers since 1844.

V. Meteorological Observations for 1883.

The following is an abstract of the observations made in 1883 at the McGill College Observatory, at Montreal, situated 187 feet above sea-level: C. H. McLeod, superintendent.

Month.	Thermometer.				*Barometer.				† Mean pressure of vapor	‡ Mean relative humidity
	Mean	Max.	Min.	Mean daily average.	Mean.	Max.	Min.	Mean daily range.		
January	5.67	39.0	-20.4	18.52	30.1917	30.649	29.272	.3473	.0545	83.01
February	13.61	44.1	-12.1	16.78	30.1716	30.755	29.527	.3638	.0710	77.90
March	16.68	48.0	- 9.8	19.65	29.9123	30.439	29.038	.3215	.0762	72.64
April	37.22	62.8	11.1	14.82	29.9555	30 449	29.602	.1992	.1453	64.40
May	50.18	81.5	32.8	16.72	29.9277	30.301	29.494	.2008	.2428	70.85
June	65.82	84.0	46.0	16.85	29.8705	30.448	29.326	.1512	.4640	72.89
July	67.33	82.8	47.8	16.93	29.8798	30.161	29.594	.1121	.4860	72.35
August	66.37	85.8	45.5	16.68	29.9610	30.343	29.596	.1263	.4564	70.30
September	56.30	78.9	35.8	17.40	30.2977	30.461	28.971	.2186	.3448	72.70
October	43.78	68.8	24.3	13.43	30.1221	30.730	29 013	.1974	.2233	74.21
November	33.91	66.9	4.9	12.96	29.9978	30.566	29.349	.2995	.1608	75.88
December	16.61	48.1	-19.4	17 24	30.0308	30.789	29.232	.2961	.0910	83.32
Means for 1883	39.452	.....	.....	16.498	30.0265	.....	.....	.....	.23384	74.162
Means for nine years ending with December, 31st, 1883	42.162	.....	.....	.....	29.9757	.....	.....	.....	.25244	73.991

Month.	Wind.		Sky clouded p. ct.	Percentage of possible sunshine	Inches of rain	Number of days on which rain fell	Inches of snow	Number of days on which snow fell	Inches of rain and snow melted	Number of days on which rain and snow fell	Number of days on which rain or snow fell
	Mean direction.	Mean velocity in miles per hour.									
January	S.W. by S.	11.63	54.7	42.5	0.34	3	20.0	16	2.31	2	17
February	W. by S.	12.61	54.4	48.0	0.51	4	17.2	16	2.80	2	18
March	W.S.W.	12.72	49.6	52.0	0.04	2	35.5	15	3.30	2	15
April	W.	11.18	60.9	60.6	0.84	10	6.7	7	1.48	2	15
May	W.N.W.	12.02	73.3	45.0	6 94	20	Inapp.	2	6.94	0	22
June	S.W. by W.	9.82	52.3	54.0	3.45	19	0.0	0	3.45	0	19
July	W.S.W.	7.91	46.9	62.2	4.72	18	0.0	0	4.72	0	18
August	S.W. by W.	9.45	44.7	61.4	1.60	13	0.0	0	1.60	0	13
September	W.S.W.	8.34	48.6		3.57	15	0.0	0	3.57	0	15
October	N.W. by N.	8.53	61.0	41.5	2.49	14	0.0	0	2.49	0	14
November	S.W. by W.	11.90	71.6	24.7	2.05	14	12.1	8	3.17	1	21
December	S.W.	12.69	68.0	27.3	1.03	6	25.5	17	3.64	3	20
Means for 1883	W.S.W.	10.733	57.17	48 31							
Totals	.....	.....	.....	....	27.58	138	117.0	81	39.47	12	270
Means for nine years ending with Dec. 31st, 1883	W. by S.	11.01 $_{00}$	60.94	....	27.10	137.1	114.1	84.8	38.59	15.6	205. 7

*Barometer readings reduced to 32° F. and to sea level. † Inches of mercury. ‡ Relative, saturation being 100. The monthly means are derived from observations taken every four hours, beginning with 3.13 a.m.

The greatest heat was 85° 8 on August 22nd; the greatest cold —20° .4 on January 6th°; the extreme range of temperature for the year was therefore 106° .2. The greatest range of the thermometer in one day was 45° on January 13th; the least range in one day was 2° .8 May 22nd. The warmest day was July 5th, the mean temperature (from max. and min.) being 70° .15; the coldest day was January 5th, the mean temperature being 15° .65 below zero. The highest barometer-reading was 30.789 on December 23rd; the lowest 28.971 on September 25th, giving a range of 1.818 inches for the year. The lowest relative humidity was 28 on May 18th and 19th. The greatest mileage of wind recorded in one hour was 45 on January 21st; its greatest velocity was at the rate of 60 miles per hour on January 18th.

The sleighing of the winter closed on April 6th. The first snow of the autumn fell on November 12th, but was inappreciable; the first noticeable snow was on November 13th. The first river-craft arrived in port on April 27th. Ferries began running on April 28th. Navigation was open on May 4th. Auroras were observed on 39 nights. Lunar coronas were observed on 3 nights; lunar halos on 14 nights; solar halos on 3 days; hoar-frost on 24 days; fogs on 10 days; thunder-storms on 16 days, and lightning without thunder on 2 days; brilliant clear red sky on 6 days.

VI. Notes on some Antiferments.*

By J. T. Donald, M.A.

The liability of many of our articles of food to change, especially in warm weather, has from very early times, incited men to seek for some substances that will prevent this change. Such substances receive the general name of antiseptics or antiferments, and many of them are well known. New compounds, or at least mixtures of well-known antiferments with new names, are at intervals presented to the public, who are assured that each new one in turn is far superior to any hitherto employed.

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* Read before the Natural History Society, Montreal, January, 1884.

During the past two years several so-called new antiseptics have been sent to me for examination. I have thought that a knowledge of their constituents, and what they really effect as antiferments, might be of interest to this Society; hence these notes.

In the autumn of 1881, I received from a gentleman interested in packing fish a sample of a substance called *Glacialine*, accompanied by a sheet describing its mode of use, and a certificate as to its value. In the words of this sheet, a pinch of glacialine will prevent a pint of milk, beer, wine or soup from turning sour, and a nine-ounce packet will enable hundreds of eggs to be kept fresh from June to Christmas; for nine ounces is suffiient to prepare a gallon of antiseptic fluid. Examination showed that the glacialine was simply boracic acid finely ground. A number of experiments made with it proved conclusively that it had antiseptic powers of a high order, yet it did not give the results that were claimed for it. Its action was not as long continued as its vendors claimed; eggs, kept in a solution of the boracic acid, however, retained their flavor, and were as good after several months as when fresh-laid; oysters remained sweet when treated with it, but the flavor was said to be impaired. At the time this substance was sent me, boracic acid was by no means a new food-preservative; it had been used for many years (as far back as 1865), both alone and mixed with alum. In London, England, it had been sold to milkmen for years under the names of *Aseptin* and *Double Aseptin*.

The next antiseptic I received, bore the name of *Ozone*, although it was a black powder. Directions for use were somewhat as follows:—"Place water in which the articles are to be preserved in a suitable vessel, put a quantity of the ozone in a dish, which is to be floated on the water; then set fire to the ozone, covering the vessel and admitting only a small quantity of air. After the ozone has ceased to burn, the liquid is to be stirred and is ready for use." An examination of this so called ozone showed it to be a mixture of sulphur and carbonaceous matter. When the mixture was ignited sulphurous anhydride was produced and, this dissolving in water, rendered it more or less antiseptic. The antiseptic properties of sulphurous anhydride (the gas obtained by burning sulphur) have been known for a very long time. The gas

acts by destroying the germs whose growth causes fermentations, disease and decay, and for this reason it is used for fumigating apartments. The curious thing about this ozone is its name, for, to the chemist, ozone is the name of an allotropic form of oxygen.

The third sample of food-preservative received bore simply the name of *Antiferment* and is intended for preserving wine, beer, and cider. It is composed chiefly of common salt and sodic carbonate, with a very small quantity of salicylic acid. The gentleman who sent the sample informed me that, so far as he had been able to test the material, it did satisfactorily what was claimed for it. Through what length of time it acts, I cannot say. Two of its ingredients, viz: salt and salicylicacid, are both well known as food-preservers, and it is quite credible that the two, acting in conjunction, may very powerfully oppose fermentation. The manufacturers of Antiferment advertise that they prepare several brands of food-preservatives, each for a specific purpose; that for the keeping of meat is called *Viandine*. *Science* for Sept. 14, 1883, contains a note on viandine, in which the composition is said to consist of sixty-seven parts of a mixture bora boracic acid, and fifteen parts of chloride of potassium and eighteen parts of water.

The same journal further states that numerous trials had been made with viandine, and that, whilst it to a certain extent prevented putrefaction, it by no means accomplished what was claimed it, and could not be recommended for preserving meat.

The last antiferment to which I have had my attention called is name *Boroglyceride*. It was first prepared, I believe, by Prof. Barff, the original inventor of the well-known Bower-Barff process for rendering iron rustless. Boroglyceride, as its name indicates, is composed of boracic acid and glycerine, and is a hard, brittle solid, somewhat resembling ice in appearance. Since boracic acid and glycerine are both well-known antiseptics, we should naturally expect that a compound of the two would be very useful for preventing fermentation. There are many who are loud in their praises of boroglyceride, and not without cause, if the substance acts as effectually as Prof. Barff, who is worthy of credence, assures us it does.

With this preparation the inventor sent cream from England to Zanzibar, passing through the hot climate of the Red Sea, and

on being eaten in Africa it had not at all deteriorated. By means of it he has kept cream perfectly sweet and good for eighteen months. Pigeons treated with boroglyceride were sent from Bermuda to England, and kept there for several months without change, while sardines, by means of the preparation, were brought from Spain without any loss of flavor. Prof. Barff claims that his antiferment is not in any way injurious to health. In proof of this claim, he states he has for a year and a half given a member of his family daily the greater part of a quart of cream treated with one ounce of the boroglyceride, and no injurious effects were noticed. During a whole summer the pupils of a college, to the number of two hundred, used milk treated with boroglyceride; its presence was not detected by any of them, nor was there the slightest sign of ill-health arising from its use. It would seem that this last mentioned antiferment is the best yet introduced, and it may be expected to prove a boon to the public.

VII. Notes on Eozoon Canadense.

By J. W. Dawson, C.M.G., F.R.S.

(*Abstract of a paper read before the British Association at Southport*, 1883).

The oldest known formation in Canada is the Ottawa gneiss, or fundamental gneiss, a mass of great but unknown thickness, and of vast area, consisting entirely of orthoclase gneiss, imperfectly bedded and destitute of limestones, quartzite or other rocks which might be supposed to indicate the presence of land-surfaces and ordinary aqueous deposition. It constitutes the lower part of the Lower Laurentian of Logan, and may be regarded either as a portion of the earth's original crust, or as a deposit thereon by aqueo-igneous agency and without any evidence of derivative deposits.

Succeeding this is a formation of very different character though still included in the Lower Laurentian of Logan. It has been named the Grenville series, and includes beds of limestone, quartzite, iron ore, and graphitic and hornblendic schists, with evidence locally of pebble-beds. It is in this, and espcially is one of its great limestones, the Grenville limestone, that *Eozoon Canadense* occurs. It has been shown that these limestones are regu-

larly bedded and of great horizontal extent. The Grenville formation presents lithological evidences of ordinary atmospheric erosion of the older rocks, and of ordinary aqueous as well as organic deposition.

Above this is the Norian series of Hunt, or Upper Laurentian of Logan, in which lime-feldspar rocks become dominant, and show that the calcareous rocks accumulated in the preceding period were already contributing to the material of new deposits. No evidence of Eozoon has been found in this series, which is, thus far, entirely unfossiliferous. The Huronian and other series, also of Eozoic or pre-Cambrian rocks, succeed to the Norian, and in one of these, the Hastings group, belonging probably to the Taconian of Hunt, specimens of Eozoon and indications of worm-burrows and other obscure fossils have been found.

With reference to the mode of preservation of Eozoon, it was stated that in its ordinary condition, as mineralised by serpentine, it presents the simplest kind of mineralisation of a calcareous fossil; that in which the orignal calcite walls still exist, with no change except a crystallisation of the calcite, common in the fossils of newer formations, and with the cavities filled with a hydrous silicate, which was evidently in process of deposition on the sea-bottom on which Eozoon is supposed to have lived. Commencing with this fact, the author proceeded to show that the various imperfections and accidents of preservation observed in Eozoon are precisely parallel to those observed in palæozoic and mesozoic fossils.

In conclusion, it was stated that many new observations had been made by Dr. Carpenter and the author, and would appear in a memoir now in course of preparation by the former, and that the author hoped, on the occasion of the visit of the British Association to Canada next year, to exhibit to those interested in the subject the large series of specimens of Eozoon now in the museum of McGill University.

VIII. Botanical Notes.

Six-leaved Clover.—A specimen of six-leaved clover, possessing some features of interest, was found in Mount Royal Park by Miss Van Horne, on June the 6th. Upon examination, the leaflets appeared to be united to the petiole in two distinct groups of three each. The petiole was also flattened and had a width about twice that of its thickness, while a strongly defined median furrow gave unmistakable evidence that the monstrosity was developed by union of the two leaves in the bud throughout the entire length of their petioles. Furthermore, it was found that there was only one pair of stipules instead of two, or their rudiments, as might have been expected; but this pair, instead of being lateral to the base, as in a normal petiole, were median along the central furrow, or in other words, they represented the survival of the two interior stipules along the line of union, and the suppression of the external stipule in each petiole.

D. P. P.

Tension.—An interesting case of tension developed through conjunctive growth, was observed during the month of May in a large elm tree at Abbotsford, P.Q., on the land of Mr. Chas. Gibb. It appears that, originally, the tree forked a short distance above ground, and the main limbs thus formed continued to grow at a slightly diverging angle. As the two structures mutually approached through co ntinued growth in diameter, the bark of their inner faces came in contact, and caused a compression which finally arrested further increase in that direction, but forced the new growth out laterally. Thus, in time, the two trunks came to present a plano-convex section, separated at their plane surfaces by the persistent bark. Through excessive lateral growth, and the added influence of strong internal tension, the now closely approximated lateral edges of the two limbs ruptured their bark and affected a complete union, thereby enclosing the original bark of the two, in a firm and constantly thickening case of wood. The compression increased with growth, and finally brought the two layers of bark into a high state of tension, which was made quite conspicuous at the time the tree was cut. When the first section was made the compound trunk was found to be nearly square in outline, with the extreme length of the diagonals 98 c. m. and 85 c. m., while the line of internal fissure, which

coincided with the longer diagonal, was found to be 87 c. m. long and 1.9 c. m. at its greatest width. The included bark was so strongly compressed as to be very solid. With the second cut, the tension was largely released, and the crack almost immediately opened to 5.5. c. m. at its greatest width.

D. P. P.

Sisyrinchium bermudiana.—On first seeing the specimens of Sisyrinchium collected in the Bermudas, by Sir J. H. Lefroy and Mr. Moseley, I suspected that they were specifically different from the plant commonly known as *Sisyrinchium bermudiana*, and after comparing them with numerous specimens of the plant so called from eastern North America, I was convinced that such was the case. Referring to the literature of the subject, I found this view supported by all the early writers who had actually seen the Bermudan plant. The history of the two species concerned is soon told. Towards the end of the seventeenth century Plukenet figured and briefly described what he termed the Bermudan and the Virginian Sisyrinchii, the types of which are still preserved in the Sloane Herbarium at the British Museum. Dillenius, who had opportunities of seeing living plants at Eltham, followed Plukenet in distinguishing these two species, and published better figures and more complete descriptions of them in the 'Hortus Elthamensis.' Linnaeus, who we assume did not see the Bermudan plant, as there is no specimen in his herbarium, united the two, as varieties of one, under the name of *S. bermudiana*. Miller, who seems to have been the most accomplished English botanist of his day, was the first to restore the two forms to specific rank. This was in 1771. In 1789 Curtis figured the true Bermudan plant, and insisted upon its specific rank, remarking that he had living plants before him of both the species figured by Dillenius. Unfortunately he gave it a new specific name, for which he afterwards expressed his regret. The first De Candolle wrote the text to the excellent figure of the Bermudian plant, which was published in Redouté's Liliacées, at the beginning of the present century, and he particularly points out its distinctive characters. I have not taken the trouble to turn up every book in which the two species are likely to be mentioned, and I have not ascertained who was the first botanist to re-unite them; but the North American botanists seem to be agreed

that there is only one species of Sisyrinchium in the Eastern States, and this they designate *S. bermudiana.* The error probably arose in consequence of the Bermudian plant disappearing from European gardens, though the name was retained. *S. bermudiana* requires the shelter of a greenhouse in this country, not merely to protect it from frost, but also to enable it to attain its full development, while *S. angustifolium*, the other species, is perfectly hardy and grows like grass. Curtis, having been deceived by its behavior during a very mild winter, at first stated that the Bermudian plant was hardy, an assertion that he recalled in the letter-press accompanying the figure cited below of his S. *gramineum.*

The synonymy of the Bermudian plant follows.—

SISYRINCHIUM BERMUDIANA Linn. Sp. Pl., ed. i. p. 954 (quoad β tantum); Miller, Dict.. ed. 6; Lamarck Encycl. Method. Bot. i., p. 408; Redouté) Lill. t. 149. Sisyrinchium *bermudense* floribus parvis, ex cæruleo & aureo mixtis; Iris Phalangoides quorundam; Plukenet, Almagestum, p 348 et Phytogr., t. 61, fig. 2. Bermudiana Iridus folio, fibrosa radice, Tournefort Inst. Rei Herb., p. 388, t. 108; Dillenius, Hort. Elth., p. 48, t. 41, fig.48.

Sisyrinchium iridioides, Curtis. Bot Mag., t. 94.

Sisyrinchium bermudianum, var. 1, Baker in Journ. Linn. Soc, Lond., xvi, p. 117.

Endemic in the Bermudas.

Besides the Bermudian specimens alluded to above, there are cultivated specimens at Kew from the herbarium of Bishop Goodenough, presented by the corporation of Carlisle.

Sisyrinchium bermudiana differs from *S. angustifolium* in being much larger in all its parts, and strikingly so in its broad leaves, which are equitant at the base; hence Curtis's name *iridioides.* It grows eighteen to twenty-four inches high, and is stout in proportion. The flowers are large, and the broad segments of the perianth are obovate-mucronate; but I have not been able to compare the flowers, as there are none of the Bermudian specimens in a satisfactory state. However, a comparison of the figures cited should be sufficient to convince any one of their specific diversity.

With regard to the forms of Sisyrinchium from eastern North America, if they are all to be regarded as belonging to one species, (and we have the authority of the leading botanists in the States for considering them as such,) Miller's name, being the earliest, is the one to adopt.

SISYRINCHIUM ANGUSTIFOLIUM Miller, Dict., ed. 6 (1771).
Sisyrinchium anceps Cavanilles, Dissert. vi, p. 345, t. 190, fig. 2 (1788).
Sisyrinchium gramineum Curtis, Bot Mag., t. 464(1799).
Sisyrinchium mucronatum Michaux, Fl. Bor-Am. ii, p. 33 (1803).
Sisyrinchium bermudiana Linn., Sp. Pl., ed. i, p. 954 excl. *β. bermudense.*
Sisyrinchium bermudiana, A. Gray, Man. Bot. Northern U. S., ed. 5, p. 517; Chapman, Fl. Southern U. S., p. 474; Baker in Journ. Linn. Soc. Lond., XVI, p. 117, excel. var.1.
Sisyrinchium cæruleum parvum gladiato caule *Virginianum*: Plukenet, Almagestum, p. 348, et Phytogr., t. 61. fig. 1.
Bermudiana graminea, flore minore cæruleo: Dillenius, Hort. Elth., p. 49, t. 41, fig. 49.

Common in the Eastern States of North America from Massachusetts to Florida, and naturalized in the Mauritius, New Zealand, and Australia. It also occurs in Ireland, where it is reported to be spreading; and as it so readily colonizes, it has been considered as an introduced plant, though, on the other hand, the North American *Eriocaulon septangulare* is generally admitted to be indigenous in Ireland. Since the above has been in type, Dr. Asa Gray has directed my attention to the fact that Mr. Sereno Watson pointed out, as long ago as 1877 (Proc. Am. Acad. Sc. xii, p. 277), that the Bermudian Sisyrinchium is a distinct species; but as he neither elaborated the synonymy of the species nor explained that the Linnean *S. bermudiana* was a composite one, he has only so far anticipated me that he recognized the Bermudian plant as different from the North American.— *W. B. Hemsley*, in American Naturalist for June, 1884.

IX. PROCEEDINGS OF THE NATURAL HISTORY SOCIETY.

The first ordinary meeting of the Natural History Society of Montreal for the session 1883-84 was held on the evening of Monday, 29th October; the president, Dr. T. Sterry Hunt, in the chair. After routine business, Mr. G. L. Marler exhibited specimens of the osprey, wood-duck and blue-bird, presented to the museum by Mr. W. L. Marler, St. Johns, Que. The thanks of the society were given Mr. Marler for his donation.

Messrs. W. H. Rintoul, and W. P. J. Bond were elected ordinary members, and Messrs. J. H. R. Molson, J. O. Robert, J. Jack and Prof. D. P. Penhallow were proposed for membership.

Dr. T. Sterry Hunt then gave an account of "Igneous and Aqueous Theories in Geology," after which a general discussion on this topic followed.

The second meeting was held on Nov. 26th; the president in the chair. Four birds were presented to the museum, viz.: A velvet duck from Mr. J. L. Macdonald of St. Johns, and three specimens of the Napoleon gull by Mr. G. L. Marler,

Messrs. J. H. R. Molson, J. A. Robert, J. Jack and D. P. Penhallow were elected ordinary members of the society; and Messrs. J. H. R. Molson and J. H. Burland life-members.

Dr. Osler then made a communication on "The Brain of the Seal," illustrated by many prepared specimens of the brains of this and other animals.

The third meeting was held on January 28th. In the absence of the president, Major Latour occupied the chair. Messrs. Marler, Molson and Latour were appointed a committee to ascertain on what conditions Messrs. Dawson Bros. would permit the use of the title of "The Canadian Naturalist" for the society's journal.

Dr. Harrington presented to the library a copy of his "Life of Sir W. E. Logan," and Mr. W. L. Marler, of St. Johns, Que., presented the museum with a specimen of the saw-whet owl, for both of which gifts the thanks of the society were voted.

Dr. Harrington, Mr. Beaudry, Dr. Hingston and Mr. Marler were appointed a committee to prepare an address to the Governor-General, asking him to become the patron of the society.

Messrs. F. B. Caulfield, J. J. Robson, E. A. Robert and G. Young were proposed as ordinary members.

Mr. J. T. Donald read a paper in "Some Antiferments" which is published in this number of The Record, and also presented notes on a clay found at Côte St. Luc, and on the occurence of the mineral samarskite in the county of Berthier, Que.

(The continuation of the Proceedings will appear in the next number.)

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VOLUME I. NUMBER 2.

THE CANADIAN

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INCLUDING THE PROCEEDINGS OF

THE NATURAL HISTORY SOCIETY OF MONTREAL,

AND REPLACING

THE CANADIAN NATURALIST.

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THE

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MONTREAL.

VOLUME I. ... ... NUMBER 2.

I. THE APATITE DEPOSITS OF CANADA.*

BY T. STERRY HUNT, L.L.D., F.R.S.

The presence of apatite in the Laurentian rocks of North America has long been known to mineralogists, and within a few years so much interest has been excited by the economic importance of deposits of this mineral, found in certain parts of Canada, that a brief history of our knowledge of these deposits may not be unacceptable to the members of the 'American Institute of Mining Engineers. It was in 1847 that the present writer was shown by a local collector of minerals some large crystals, which had been called beryl, found in North Burgess, in Ontario. These were at once recognized as apatite; and after a visit to the locality, this was described in the report of the geological survey of Canada for that year as likely to furnish an abundant supply of a valuable fertilizer: the opinion being then expressed that the fact of "the existence of such deposits as these will prove of great importance."

Specimens of apatite from this locality, collected by the writer, were shown among the economic minerals of Canada at the great

* Read before the American Institute of Mining Engineers, at Cleveland, February, 1884, and reprinted from its Proceedings.

exhibitions of London and Paris in 1851 and 1855, and the mineral had already been found by explorers at several other points in the same region previous to 1863. In the *Geology of Canada*, published in that year, the writer resumed the results of his further studies of these deposits, and described the apatite as occurring in the Laurentian rocks, both distributed in crystals through carbonate of lime, and in "irregular beds running with the stratification and composed of nearly pure crystalline phosphate of lime." This was further said to occur in North Burgess, in several parallel "beds interstratified with the gneiss."*

In a subsequent report of the geological survey, in 1866, I again noticed the occurrence of the apatite in beds in the pyroxenic rocks often found associated with the gneiss. It was said, "the presence of apatite seemed characteristic of the interstratified pyroxenic rocks of this section, in which it was very frequently found in small grains and masses, alike in the granular and the micaceous schistose varieties." In these rocks, the apatite was said to mark the stracification, and to form, in one example, a bed, in some parts two feet thick, which was traced 250 feet along the strike of the pyroxenic rock. I at the same time described the occurrence of apatite, often with calcite, in "true vein-stones, cutting the bedded rocks of the country;" alike gneiss, pyroxenite, and crystalline limestone. These latter deposits were farther spoken of as well-defined veins, traversing vertically, and nearly at right angles, the various rocks; as often banded in structure, and including besides apatite both calcite and mica, occasionally with pyroxene, and more rarely with hornblende, wollastonite, zircon, quartz, and orthoclase. These veins were said to be very irregular, often changing rapidly in their course from a width of several feet to narrow fissures. It was added, "it is evident that this district can be made to supply considerable quantities of apatite;" and while the uncertainties arising from the irregularities of the veins were mentioned, it was said that "some of the deposits might probably be mined with profit."†

Before following farther this history, it may be stated that there are two districts in Canada which have, within the past few

* Loc. cit, pp. 592, 761.

† Loc. cit., pp. 304, 234, 239.

years, been found to contain deposits of apatite of economic importance; one in the province of Ontario, in which the above observations were made by the writer previous to 1866, including parts of the counties of Lanark, Leeds, and Frontenac; and the other, since made known, in the province of Quebec, chiefly in Ottawa county. In both cases it is found in the rocks of the Laurentian series, consisting of granitoid gneisses with bands of quartzite, of pyroxenite, and of crystalline limestone. These ancient and highly inclined strata, with a northeast strike, rise from beneath the horizontal paleozoic rocks near Kingston, and again pass beneath them near Perth. These overlying strata belonging to the Ottawa basin, hide, moreover, to the eastward, the apatite-bearing gneisses of this district; which, a short distance to the westward, are again concealed by the Taconian and other overlying pre-Cambrian groups in Hastings county. The gneissic belt is here seen chiefly in the the townships of Loughborough, Storrington, Bedford, North and South Crosby, and in North Burgess, where the apatite was first discovered.

The country presents a succession of small, isolated, rounded, rocky hills, alternating with numerous small lake-basins, hollowed out of the gneiss, and sometimes out of the interstratified limestones; the general trend both of the hills and the lakes being coincident with the strike of the rocks. These, though concealed in the valleys by considerable depths of alluvial soil, are seen in the hills to be hard and undecayed. These geographical features, as I have elsewhere pointed out, wer apparently determined by sub-aërial decay previous to the erosion which removed from them the softened and disintegrated portions, leaving the present outlines.*

When, after cutting the forest-growth which covers these hills of granitoid gneiss, fire is allowed to pass over the surface, destroying the undergrowth, the comparatively thin layer of soil is laid bare and is soon washed away by the rains; leaving the bald rocky strata exposed in a manner singularly favorable for geological study, but rendering the region sterile. To prevent this process of denudation it has become the practice in some parts of the country, after burning over the hillsides, to sow them, without

* See the author's paper on "Rock Decay Geologically Considered."—*Amer. Jour. Sciences*, Sept., 1883.

loss of time, with grass-seed, which, at once taking root, protects the soil from the destructive action of rains, and transforms it into good pasture-land. This system, which has been adopted to a considerable extent in parts of Frontenac county, Ontario, is worthy of record and of imitation in other regions.

The similar apatite-bearing gneisses, which are found to the north of the river Ottawa, a little northeast of the city of that name, are in Ottawa county, Quebec, and chiefly in the townships of Buckingham, Templeton, and Portland. They reproduce all the characteristics of the first mentioned district, and may be looked upon as a prolongation of it beneath the northwestern limb of the paleozoic basin already mentioned. Later observations, both in Ontario and in this latter district, where mining operations have been carried on within the past few years, have been recorded by Messrs. Broome and Vennor, and by Dr. Harrington,—the latter up to 1878. They have, however, added little to our knowledge of the conditions of occurrence of the mineral beyond what had already been set forth in 1863 and 1866.

I have, within the past few months, examined with some detail many of the apatite-workings in Ontario, which have served to confirm the early observations, and to give additional importance to the fact, already insisted upon in previous descriptions, that the deposits of apatite are in part bedded or interstratified in the pyroxenic rock of the region, and in part are true veins of posterior origin. These gneissic rocks, with their interstratified quartzose and pyroxenic layers, and included bands of crystalline limestone, have a general northeast and southwest strike, and are much folded; exhibiting pretty symmetrical anticlinals and synclinals, in which the strata are seen to dip at various angles, sometimes as low as 25° or 30°, but more often approaching the vertical. The bedded deposits of apatite, which are found running and dipping with these, I am disposed to look upon as true beds, deposited at the same time with the inclosing rocks. The veins, on the contrary, cut across all these strata and, in some noticeable instances, include broken angular masses of the inclosing rocks. They are, for the most part, nearly at right angles to the strike of the strata, and generally vertical, though to both of these conditions there are exceptions. One vein, which had yielded many hun

dred tons of apatite, I found to intersect, in a nearly horizontal attitude, vertical strata of gneiss; and in rare cases what appear, from their structure and composition, to be veins, are found coinciding in dip and in strike with the inclosing strata.

The distinction between the beds and the veins of apatite is one of considerable practical importance,—first, as related to the quality of the mineral contained, and second, as to the continuity of the deposits. The apatite of the interbedded deposits is generally compactly crystalline, and free from admixtures, although in some cases including pyrites, and more rarely magnetic iron-ore, with which it may form interstratified layers. Many will recall in this connection the band of magnetite, with an admixture of granular apatite, found interstratified in parts of the great magnetic ore-deposit known as the Port Henry mine, near Lake Champlain, in Essex county, New York; where in certain layers formerly mined, the apatite made up about one-half the bulk. I have seen an example of a similar association of magnetite and apatite from Frontenac county, Ontario. The latter mineral is, however for the most part found included in the beds of pyroxene rock, already mentioned, which is generally pale green or grayish green in color, sometimes containing quartz and orthoclase, and distinctly gneissoid in structure.

The veins present more complex conditions; while they are often filled throughout their width by apatite as pure and as massive as that found in the beds, it happens not unfrequently that portions of such veins consist of coarsely crystalline sparry calcite, generally reddish in tint, holding more or less apatite in large or small crystals, generally with rounded angles, and often accompanied by crystals of mica, and sometimes of pyroxene and other minerals. Occasionally these mixtures, in which the carbonate of lime generally predominates, will occupy the whole breadth of the vein. These *lime-veins*, as they are called by the miners, sometimes include cavities from which the carbonate appears to have been dissolved by infiltrating waters, leaving free the inclosed crystals of apatite. In some cases, however, these veins present cavities which have apparently never been filled with solid matter, and exhibit drusy surfaces, with quartz, and more rarely with barytine and zeolites. The calcareous veins often carry so much carbonate of lime as to be valueless for commercial purpos-

es, unless some cheap means for separating the apatite can be devised. It may be said, in general terms, that while some of these true veins throughout portions or the whole of their breadth yield good and pure apatite, others are of comparatively little value. The bedded masses, on the contrary, are free from carbonate of lime, and although they may occasionally contain small quantities of mica, pyroxene, hornblende, or pyrites, these are seldom present to an injurious extent.

The question of the continuity of these deposits of both classes is an important one. Veins filling fissures that have been formed in rocks are sometimes continuous for great lengths and to great depths, but experience shows that their extent varies very much for different regions and for different rocks. Inclined beds, which were once horizontal sheets, inclosed in strata that have since been folded, should be as persistent in depth as they are in length; and when traced in the outcrop for many hundreds of feet, may be expected, under ordinary circumstances, to continue downwards as far, unless a turn of the inclosing strata bring them up again to the surface. The inclosed beds of apatite in the regions already noticed are often traced for 500 to 1000 feet and more, and there is reason to believe that they are continuous for long distances. The workings upon them have, however, as yet been very superficial, generally from twenty to forty feet, and rarely exceeding 100 feet. The deepest mine, which is in Ottawa county, is now about 200 feet.

The ordinary thickness of the bedded masses of apatite may be said to vary from one to three and four feet, though not unfrequently expanding to eight and ten feet, and even more, and sometimes contracting to a few inches; the same layer being subject to considerable variations. In some cases the apatite in a bed is found to thicken and then to diminish, or to be divided by the interposition of the accompanying pyroxenic rock. The condition of the apatite in these cases recalls the thickening and thinning sometimes observed in a layer of coal among disturbed strata, where, as the result of great pressure attending the movements of the harder inclosing rocks, it is alternately attenuated and swollen in volume; in which case a thinning in one portion is necessarily compensated for by a thickening of the parts adjacent.

The thickness of the veins also, as above stated, is very

variable, and the same vein in a distance of a few hundred feet will sometimes diminish from eight or ten feet to a few inches. We have already noticed the variable nature of the contents of these veins, which are sometimes filled with with solid and pure apatite, and at other times present bands or layers of this mineral, with others chiefly of calcite, of pyroxene crystals, or of a magnesian mica, occasionally mined for commercial purposes. While these veins have yielded in many cases considerable amounts of apatite, they have not the persistency of the beds. Their study presents many interesting facts in paragenesis, which I have described in detail in the report of the geological survey for 1866, already quoted, and more briefly in my *Chemical and Geological Essays* (pp. 208-213).

It is worthy of remark, that some of the first attempts at mining apatite in Canada were upon these veins, and that their irregularities contributed not a little to the discouragement which followed the early trials. The larger part of the productive workings are upon the bedded deposits. These, however, as already noticed, are for the most part opened only by shallow pits; a condition of things which is explained by the peculiar character and the frequency of the deposits, and also by the economic value of the apatite. This mineral, unlike most ordinary ores, is, in its crude state, a merchantable article of considerable value, and finds a ready sale at all times, even in small lots of five or ten tons. Like wheat, it can be converted into ready money, at a price which generally gives a large return for the labor expended in its extraction. Hence it is that farmers and other persons, often with little or no knowledge of mining, have, in a great number of places throughout the district described, opened pits and trenches for the purpose of extracting apatite, and at first with very satisfactory results. So soon, however, as the openings are carried to depths at which the process becomes somewhat difficult from the want of appliances for hoisting the materials mined, or from the inflow of surface-waters, which in wet seasons fill the open cuts, the workings are abandoned for fresh outcrops, never far off. In this way a lot of 100 acres will sometimes show five, ten or more pits, often on as many beds, from twelve to twenty feet deep; each of which may have yielded one or more hundred tons of apatite,

and has been abandoned in turn, not from any failure in the supply, but because the mineral could be got with less trouble and cost at a new opening on the surface near by.

These conditions are scarcely changed when miners, without capital, and unprovided with machinery for hoisting or for pumping, are engaged, as has often been the case, to extract the mineral at a fixed price per ton. These, having no interest in the future of the mine, will work where they can get the material with the least expenditure of time and labor, and often will quit the opening for some one which is more advantageous. The very abundance and the value of the mineral mined has thus led to its careless, wasteful, and unskilful exploitation. It is the working of these causes, in the way just explained, which has thrown undeserved discredit on this mining industry, and more even than the injudicious schemes of speculators and stock-jobbers, has retarded its legitimate growth.

It is evident that the proper development of these deposits will require regular and scientific mining in place of the crude plan of open pits and trenches, which, from causes already explained, has hitherto, with few exceptions, been followed. As a basis for calculation in mining, it becomes necessary to establish some data as to the production and the value of the apatite-layers which we have described. The specific gravity of the mineral, as deduced from many specimens of massive Canadian apatite, is from 3.14 to 3.24. If we assume 3.20, this will give for the weight of a cubic foot of apatite almost exactly 200 pounds. A fathom of ground, carrying a bed or vein of apatite one foot in thickness, will thus contain thirty-six cubic feet, or 7200 pounds of apatite; equal to a little over three and one-fifth tons of 2240 pounds each. Allowing the fractional portion, equal to nearly seven per cent., for loss in mining (it will be noted that coarse and finely-broken apatite are equally merchantable), we shall have as the net product of a layer of apatite for a fathom of ground mined, three gross tons for each foot in thickness.

The apatite of these deposits is generally greenish in color, often clear sea-green, but more rarely reddish brown in tint. The massive varieties are sometimes coarsely crystalline and cleavable, but sometimes finely granular. The veins often yield crystals of large size.

The mineral is essentially a fluor-apatite, containing not over two or three thousandths of chlorine and, in its purest state, about 92.0 per cent. of tricalcic phosphate. The analysis of a selected specimen gave me 91.2 per cent. of phosphate, but it is generally mingled with small portions of foreign matters, chiefly insoluble silicates, The analyses of seven specimens from different Canadian mines, published by Mr. C. G. Hoffman, in 1878, showed from 85.2 to 89.8 per cent. of phosphate.

The market-value of apatite, which, as is well-known, is chiefly consumed for the production of soluble phosphate by the manufacturers of artificial fertilizers, varies greatly, other things being equal, with its purity. Thus, while at present the price in England is 1*s.* 2*d.* the unit for apatite giving by analysis 75 per cent. of tricalcic phosphate, there is paid an addition of one-fifth of a penny for each unit of phosphate above that percentage, so that a sample yielding by analysis 80 per cent. is worth 1*s.* 3*d.* the unit. The price in the English market is subject to considerable fluctuations, having within the last four years been as high as 1*s.* 5½*d.*, and as low as 11*d.* the unit for 80 per cent. phosphate. The present may be considered as an average price.

The Canadian apatite shipped to England has yielded for various lots from 75 to 85 per cent., 80 per cent. being the average from the best-conducted mines, though lots from mines where care has been used in the dressing and selection of the mineral for shipment have yielded 84 and 85 per cent. Many of the smaller miners to which we have alluded, selling their product to local buyers, take little pains in dressing, and hence their product is apt to be lower in grade. It will be seen, from the rule adopted by foreign purchasers, that there is great profit in a careful selection and dressing of the mineral for market. The basis being 1*s.* 2*d.* the unit for 75 per cent., with a rise of one-fifth of a penny for each unit, it follows that while a ton of 75 per cent. apatite will bring only 87*s.* 6*d.*, a ton of 80 per cent. will command 100*s.*, and one of 85 per cent. 113*s.* 4*d.*

In the present state of the industry it is not easy to say what would be the cost of production. At the outcrop of the large masses of apatite, and in the open cuts and quarries already described, the cost of extraction and dressing is of course very

variable, estimates in different deposits giving from $2 to $8 the ton. In Ottawa county, where, within the last four years, deposits have been opened and mined on a better system than heretofore, the figures of production and cost are instructive. According to the report of its manager in July 1882, the High Rock mine, in Buckingham, yielded, in 1880, 2400 tons, and in 1881, 2000 tons of apatite, An adjoining portion of land having been then acquired, the production of this company's mines in 1882 and 1883 is stated at 5000 tons annually; from eighty to ninety men being employed. The cost of the mineral is here given at $4 the ton, dressed, at the mine; in addition to which $3 is paid for carriage to the railroad or the river, and about $1 additional to Montreal, the port of shipment. The mines in the Ontario district are for the most part in or near to the waters of the Rideau canal, or some of the many lakes connected therewith, from which the freight to Montreal is $1.50 the ton. I am informed by a merchant, who is a purchaser and shipper of apatite, and is also engaged in mining it both in Ontario and Quebec, that the average cost for freight from Montreal to England, with selling-charges, is 20*s.* the ton; which, for apatite of 80 per cent., now worth 100*s.* the ton, would leave 80*s.*, or $19.36. Deducting from this the cost of production and of transportation to Montreal, there remains a large profit.

The amount of apatite shipped from Montreal has gradually increased, and, according to published figures, attained in 1883, 17, 840 tons, of which, it is to be remarked that 1576 tons were delivered in Hamburg, and 650 in Stockholm, the remainder going to Liverpool, London, and other British ports. Of this about 15,000 tons were from Quebec, and the remainder from Ontario. It should be noticed that this was, with small exceptions, mined in 1882, and brought to the water-side during the winter season. It is estimated that the shipments of apatite for 1884 will equal 24,000 tons.

The methods of mining hitherto generally pursued in the apatite deposits of Canada, allow of many improvements which would materially reduce the average cost af production, and give a permanency to the industry which the present modes of working can never attain. The regularity and persistence of the bedded

deposits. and of some of the veins, warrants the introduction of systematic mining by sinking, driving, and stoping; with the aid of proper machinery for drilling, as well as for hoisting and pumping. The careful dressing and selection of the apatite for the market is also an element of much importance in the exploitation of these deposits. The cost of labor in the apatite-producing districts is comparatively low, and there are great numbers of beds now superficially opened, upon which regular mining operations, conducted with skill and a judicious expenditure of capital, should prove remunerative. It must be added, that the areas in question have as yet been very partially explored, and that much remains to be discovered within them, and also there is reason to believe in outlying districts; so that in the near future the mining of apatite in Canada will, it is believed, become a very important industry.

II. The Origin of Crystalline Rocks.*

By T. Sterry Hunt, LL.D., F.R.S.

The author began by remarking that the problem of the origin of those rocks, both stratified and unstratified, which are made up chiefly of crystalline silicates, is essentially a chemical one. He then proceeded to review the history of the once famous dispute between the vulcanist and the neptunist schools in geology, as to whether granite and other crystalline rocks were formed by igneous or by aqueous agencies, and showed from recent writers that the controversy is not yet settled. He noticed, of the igneous school, both the plutonic and the volcanic hypothesis of the origin of these rocks, and then proceeded to consider the metamorphic and metasomatic hypotheses, which would derive them, by supposed chemical changes, from materials either of igneous or of aqueous origin.

The hypothesis of Werner was next explained. This conceives all such rocks to have been successively deposited in a crystalline form from a chaotic watery liquid, which surrounded

* Abstract of a paper read before the Royal Society of Canada at Ottawa, May 20, 1884.

the primitive earth, and at an early time held in solution the whole of the materials of these rocks. The inadequacy of all of these hypotheses was pointed out, though it was said that Werner's is the one nearest the truth.

The author conceives that the crystalline rocks were formed by deposition from waters which successively dissolved and brought from subterranean sources the mineral elements. Their formation is illustrated by that of granitic veins and that of zeolites—processes regarded as survivals of that which produced the earlier rocks. The true zeolites are but hydrated feldspars, while the minerals of the pectolite group correspond to the protoxyd-silicates of these ancient rocks, often remarkably concretionary in aspect.

The source of the elements of these rocks, according to the new hypothesis here proposed, was in the superficial layer which was the last congealed portion of an igneous globe consolidating from the centre. In this primitive stratum, porous from contraction, and impregnated with water, resting upon a heated anhydrous nucleus, and cooled by radiation, an aqueous circulation would be set up, giving rise to mineral springs. The water of these dissolved and brought to the surface, there to be deposited, the quartz, feldspars, and the other silicates which, through successive ages, built up the great groups of crystalline stratified rocks.

Exposed portions of the primitive silicated material would be subject to atmospheric decay and disintegration, giving rise to aqueous sediments of superficial origin, which would become intercalated with the deposits from subterranean sources. The reactions between the mineral solutions from below and these superficial materials were doubtless important in this connection, probably giving rise to certain common micaceous minerals; while dissolved silicates allied to pectolite, by their reaction with the magnesian salts which then passed into the waters of the ocean, would generate species like serpentine and pyroxene.

This process of continued upward lixiviation of the primitive chaotic layer would result in the production of a great overlying body of stratified acidic rocks, leaving below a basic residual and much diminished portion, the natural contraction of which would cause corrugations in the superincumbent stratified mass, such as are everywhere seen in these ancient rocks.

The source of volcanic rocks is partly in this lower basic and

more or less exhausted stratum of comparatively insoluble and ferriferous silicates, whence come melaphyres and basalts; partly in the secondary or acidic zone, which, softened by the combined agency of heat and water, may give rise to granitic and trachytic rocks; and partly, it is conceived, in later aqueous deposits of superficial origin, which may also be brought within the influence of the central heat.

This attempt to explain the genesis of crystalline rocks by the continued solvent action of subterranean waters on a primitive stratum of igneous origin the author designates as the *crenitic* hypothesis, from the Greek κρηνη a fountain or spring. A preliminary statement of it was made by him to the National Academy of Sciences at Washington, April 15, 1884, and appears in the *American Naturalist* for June.

III. The Cambrian Rocks of North America.*

By T. Sterry Hunt, LL.D., F.R.S.

The writer gave his reasons for limiting the term Cambrian to the Lower and Middle Cambrian of Sedgwick, which contain the first fauna of Barrande. For the Upper Cambrian or Bala group, holding the second fauna, wrongly claimed by some as a lower member of the Silurian, and by others called Cambro-Silurian, he prefers the term Ordovician, now accepted by many British and continental geologists. This includes in New York the Chazy, Trenton, Utica and Loraine divisions; the Oneida marking the base of the true Silurian or third fauna. The Cambrian rocks of the great North-American basin may be studied in four typical areas: 1. the Appalachian; 2. the Adirondack; 3. the Mississippi; 4. the Cordillera area. To the first of these belongs the immense volume of greatly disturbed sediments along the whole eastern border of the basin, constituting the First Graywacke and the Sparry Limerock of Eaton; being the Upper Taconic of Emmons, and the Potsdam group and Quebec group of Logan. They are distinct from the unconformably

* Abstract of a communication to the Boston Soc. Nat. History' Feb. 20, 1884.

underlying Taconian quartzites, marbles and schists (Lower Taconic) which the author regards as pre-Cambrian, and the still older crystalline schists of the Atlantic belt, including those, chiefly of Huronian age, which have been called " Altered Quebec group."

The name of Taconic cannot be retained for the Appalachian Cambrian, which was, as early as 1861, correctly claimed by Emmons as belonging to the period of the first fauna. The Hudson-River group, as originally defined, included the whole of the Appalachian Cambrian, with some portions of the underlying Taconian, and others of overlying Ordovician strata, from which, in the Appalachian area, their characteristic limestones are wholly or in great part absent. It is solely from this association with the Cambrian Graywacke of strata of Loraine age that the Hudson-River group has come to be regarded as the palæontological equivalent of the Loraine shales.

In the stable and little disturbed area around the Adirondack mountains, including the Champlain and Ottawa basins, the Cambrian is represented only by the quartzites and magnesian limestones of the Potsdam and Calciferous divisions, which are shallow-water deposits, corresponding apparently to small portions only of Cambrian time. The physical conditions of the Mississippi area appear to have been similar to that of the Adirondack region. As seen to the west of Lake Superior, the lowest Potsdam beds of Hall rest unconformably upon the great Keweenian or copper-bearing series. This, although containing, as the speaker had elsewhere shown, some evidence of organic life, probably worm-burrows and sponges, cannot be claimed for the Cambrian till it shall have been shown to contain a Cambrian fauna.

In this north-western area we find, moreover, beneath the Cambrian horizon, representatives of the Laurentian and of the Norian; the latter in the typical norites, or so-called gabbros, which, near Duluth, are directly overlaid by the Keweenian, elsewhere resting on Laurentian or on Huronian rocks. There are also found in Wisconsin petrosilex-rocks of Arvonian type, with quartzites, rising from beneath the Cambrian sandstones. Typical Montalban and Huronian rocks also occur around this area, besides the group which the speaker long since called Animikie,

This great series, of many thousand feet, which is overlaid unconformably by the Cambrian sandstones, and also, according to Irving, by the Keweenian, consists chiefly of quartzites and argillites, with beds of magnetite. The remains of a sponge have been detected in a calcareous mass got by the speaker at Thompson, Minnesota, from the argillites of this series, which, in a late communication to the National Academy of Sciences, he has referred to the Lower Taconic or Taconian horizon. He now stated his conclusion, drawn from various facts, that, while these Animikie rocks rest unconformably in this region upon the Huronian, the two series have hitherto been confounded under the common name of Huronian.

[The Cambrian areas of the Atlantic coast, as seen in Massachusetts, New Brunswick and Newfoundland, not being included in the great North American basin have been omitted in the present notice. As regards the Cambrian of the Cordillera area, the studies of Arnold Hague and C. D. Wolcott in the Eureka District in Nevada, just published in the Third Annual Report of the U. S. Geological Survey, show that the paleozoic column to the top of the coal measures, as there displayed, includes, not less than 30,000 feet, marked by only one stratigraphical break, which occurs in the rocks of the second fauna. The series begins with the Prospect Hill quartzite, which, although its base is not seen, shows a thickness of 1500 feet. This is succeeded by 3000 feet of more or less magnesian limestone known by the same local name, followed by the Secret Canon shales, the Hamburg limestones and the Hamburg shales, making, in all, a series of nearly 8000 feet which are referred to the Cambrian.

The first organic remains in this series are met with in what are described as the Olenellus shales, which lie between the basal quartzite and its overlying limestones, and contain a fauna closely related to that of the slates of Georgia, in Vermont, called Lower Potsdam by Billings. In the succeeding limestones and slates already named there is found at various horizons an abundant fauna resembling that of the Potsdam of the Mississippi area. We have thus in the Cordilleras, in conformable succession, the Lower and Upper Potsdam divisions of the east. The forms of the first fauna, pass upwards from the Hamburg slates ome distance into the great overlying Pogonip limestone, which

is 2700 feet in thickness, and contains higher up a fauna compared with that of the Chazy, together with some forms characteristic of the Trenton, the succession thus showing a gradual passage from the first to the second fauna.]

For the better understanding of the above remarks, and of the relation of the American Cambrian in its eastern area to the Ordovician and Silurian above and the Taconian and still older Eozoic series below, we append a tabular view from the author's memoir on *The Taconic Question, Part I.*, recently published in the first volume of the Transactions of the Royal Society of Canada. In this table are seen the classification and nomenclature proposed by Amos Eaton half a century since, together with the more recent names. The Potsdam sandstone, which in parts of the Adirondack area forms the base of the Cambrian, had not at that time been recognized.

(*See next page.*)

Classification and Nomenclature of North American Rocks.

	Eaton's Nomenclature (1832.)	Later Names.
III. Lower Secondary.	3. Corniferous Lime-rock Geodiferous Lime-rock	Upper Helderberg — **Devonian.**
	2. Millstone-grit 1. Graywacke slate — **Second Graywacke.**	Niagara, Oneida—Medina — **Silurian.** Utica—Loraine, Chazy—Trenton — **Ordovician.** (Upper Cambrian.)
II. Transition.	3. Metalliferous Lime-rock Sparry Lime-rock. Calcifer. Sand-rock.	**Upper Taconic.** (Quebec Group.) — **Cambrian.** (Middle and Lower Cambrian)
	2. Millstone-grit Graywacke-slate — **First Graywacke.**	
	1. Argillite	
I. Primitive.	3. Granular Lime-rock	**Lower Taconic.** — **Taconian.**
	2. Granular Quartz-rock	
	1. Gneiss and other Crystalline Rocks	**Huronian. Montalban. Laurentian. Norian. Arvonian.**

IV. The Eozoic Rocks of North America.*

By T. Sterry Hunt, LL.D., F.R.S.

According to the author there is found among the pre-Cambrian strata of North America an invariable succession of crystalline stratified rocks, which have been by him divided into several great groups, the constituents of which become progressively less massive and less crystalline until we reach the sediments of paleozoic time, of which the Cambrian is regarded as the basal member. Since all of these pre-Cambrian rocks, with the exception, perhaps, of the lowest or fundamental gneiss, present evidences, direct or indirect, of the existence of organic life at the time of their deposition, it seems proper to include them under the general title of Eozoic, proposed by Sir J. W. Dawson. That of Archæan, employed by some geologists to designate these pre-Cambrian rocks, appears too indefinite in its signification, and, moreover, is not in accordance with the nomenclature generally adopted for the great divisions succeeding. These Eozoic rocks include both the Primitive and the Transition divisions of Werner.

We distinguish at the base of the Eozoic series a massive and essentially granitoid gneiss. To this fundamental rock, sometimes called the Ottawa gneiss, and of unknown thickness, succeeds what has been named in Canada the Grenville gneissic series, made up in great part of gneiss somewhat similar to that last mentioned, with intercalations of hornblendic gneiss, of quartzite, of pyroxenite, of serpentine, of magnetite, and of crystalline limestones, the latter often magnesian, occasionally graphitic, and sometimes attaining thicknesses of a thousand feet or more. This Grenville series, the strata of which are generally highly inclined, has an aggregate volume of not less than 15,000 or 20,000 feet, and appears to rest unconformably upon the fundamental or Ottawa gneiss. This gneissic series, with its intercalated limestones, some of which contain *Eozoön canadense*, was the typical Laurentian of Logan and Hunt, named by them in 1854, with which they included, at that time, however, not only the underlying fundamental gneiss, but an upper granitoid and gneissoid series,

* Abstract of a paper read before the British Association for the Advancement of Science, Montreal, Sept. 1, 1884.

composed in large part of plagioclase feldspars, chiefly labradorite. These three divisions of the Eozoic system were thus confounded under the common name of Laurentian until, in 1862, the last was separated under the provisional name of Upper Laurentian, the two other divisions united being called Lower Laurentian. The synonym of Labradorian was subsequently, for a time, employed by Logan to designate the upper division, until 1870, when the present writer proposed for it the name of Norian, retaining that of Laurentian for the two lower divisions. It will probably be found desirable to separate the typical Laurentian or Grenville series, as studied and mapped by Logan, Hunt and Dawson, from the less-known fundamental or Ottawa gneiss, and to make of this latter a distinct gronp. The name of Middle Laurentian, sometimes given to the typical Laurentian, loses its significance with the disappearance of that of Upper Laurentian, now replaced by Norian.

The Norian series is made up in great part of granitoid or gneissoid rocks, composed essentially of plagioclase feldspars, without quartz but with a little pyroxene or hypersthene, often with titanic iron ore, and apparently identical with the norites of Norway. With these rocks are, however, found alternations of gneiss, of quartzite and of crystalline limestone, scarcely different from those of the Laurentian. We therein find also a granitoid rock made up of pink orthoclase and quartz, with bluish labradorite. This Norian series is found in many places covering considerable areas, and apparently resting in discordant stratifications upon the typical Laurentian. Its thickness has been estimated at over 10,000 feet.

There is found in certain localities a series of stratified rocks, composed essentially of petrosilex or hälleflinta, often passing into a quartziferous porphyry. There are found with it strata of vitreous quartzite, and thin layers of soft micaceous schists, besides great beds of hematite, and more rarely layers of crystalline limestone. This group, which has a thickness of many thousand feet, was at first included by the writer in the lower part of the succeeding Huronian series, which, however, apparently overlies it unconformably. Its relations with the preceding groups have not been observed, but, as it appears to be identical, both in position and in character, with what, in 1878, was first called Arvonian in Wales, we designate it by that name.

Next in order comes the group to which the writer, in 1855,

gave the name of Huronian. It differs from those preceding by the frequent presence of schistose rocks, and of conglomerates which contain fragments of the underlying gneisses. These characters, which are common to the Huronian and the two succeeding groups, led some earlier geologists in America to include them among Transition rocks. The Huronian contains a considerable proportion of epidote, hornblende and pyroxene, and is marked by varieties of diabasic rocks often called gabbros, which are truly stratified, but are not to be confounded with the norites of the Norian series, to which the name of gabbro is also frequently given. The Huronian series moreover includes imperfect gneisses, quartzites, dolomite, serpentine and steatite, besides large amount of chloritic, micaceous and argillaceous schists. Its thickness is estimated at about 18,000 feet, and it is often found resting unconformably upon the gneiss of the Laurentian. The Huronian appears to be identical with much of what has since been called Pebidian in the British Isles, and with the true *pietri verdi* group of the Alps, there found in many parts between the ancient gneisses below and a younger series of gneisses and mica-schists.

There is met with in North America a similar series to these, to which, in 1870, the writer gave the name of Montalban, because it is found largely developed in the White Mountains of New England. This series contains fine-grained white gneisses, sometimes porphyritic, but distinct from the granitoid gneisses of the Laurentian, and passing into granulites on the one hand, and into very quartzose coarse-grained mica-schists on the other. It also includes hornblendic gneisses and black hornblende-schists, together with serpentine, chrysolite rocks, dichroite-gneiss and crystalline limestones. The mica-schists of the series often contain garnets, andalusite, fibrolite, cyanite, and staurolite; while in the granitic veins which traverse the series are found tourmaline, beryl and cassiterite. The total thickness of the Montalban is apparently much greater than that assigned to the Huronian, upon which it sometimes rests unconformably, or, as is often the case in the absence of this, directly upon the Laurentian. We come next to a series composed essentially of quartzites, limestones, and micaceous and argillaceous schists. The quartzites, occasionally conglomerate, are sometimes vitreous, sometimes granular and often micaceous, passing into mica-schists

very distinct from those of the Montalban. The mica is often damourite or sericite, and gives rise to unctuous glossy schists passing into argillites, which sometimes contain a feldspathic admixture. The limestones of this series, often magnesian, are crystalline and include statuary marbles and cipolinos. We find in the schists, which are intercalated alike among the quartzite and the limestones of this series, masses of serpentine and of ophicalcite, and occasionally of chloritic and hornblendic minerals, as well as siderite, magnetite and hematite, the iron-oxyds being often mingled with the quartzites. These last are sometimes flexible and elastic, and the whole series much resembles the Itacolumitic group of Brazil. It has a thickness in different parts of North America of from 4,000 to 10,000 feet, and is found lying unconformably alike upon the Laurentian, the Huronian and the Montalban. There are found in the quartzites of this series the impressions of Scolithus, and in the limestones other undetermined forms. This is the Lower Taconic series of the late Dr. Emmons, which we distinguish by the name of Taconian. Some late writers have by mistake confounded it with the Upper Taconic of the same author, a distinct group, which Emmons declared to be the equivalent of the primordial (Cambrian) of Barrande. The Taconian is widely spread in eastern North America, and appears to be also represented around Lake Superior by what has been called the Animikie series. There is reason to believe that, on account of certain lithological resemblances between the Taconian and the Huronian, the two have been in some localities confounded, and that portions which have been called Huronian are really Taconian. The latter, the writer has elsewhere compared with a great series of similar schists and quartzites, including serpentine, anhydrite, dolomite and marbles, greatly developed in northern Italy, where it overlies the younger gneissic and mica-schists series, and has been by various observers successively referred to the mesozoic, the paleozoic and the eozoic periods.

It now remains to say something upon the relations of these different crystalline eozoic series to the Cambrian which succeeds them. Forty years since there were two schools among American geologists. One of these schools admitted the existence, between the ancient gneissoid rocks (subsequently named Laurentian and

Norian) and the fossiliferous limestones of the second fauna (Ordovician), of nothing more than those Cambrian subdivisions known as the Potsdam sandstone and the Calciferous sandrock, which in the vicinity of the Adirondack Mountains separate these ancient crystalline rocks from the Ordovician strata.

The other school of stratigraphists recognized the existence, in this interval, in the region to the east of Lake Champlain, of several series of crystalline rocks, including what we have already described under the names of Arvonian, Huronian, Montalban and Taconian, besides a younger series of uncrystalline sediments of great thickness, designated by Eaton as the First or Transition Graywacke. This was by him declared to be separated by the limestones of the second fauna from the Secondary Graywacke, a series closely resembling the Transition Graywacke. The first-mentioned school denied the existence of the Transition Graywacke, and maintained that the group thus designated was identical with the Secondary Graywacke. The geologists of this school further supposed that all the different series of crystalline rocks just named were nothing more than the same Secondary Graywacke, with the addition of the underlying fossiliferous limestones, in a state of alteration more or less profound; the series in different areas assuming successively the character of Taconian, Montalban, Huronian, and even, as some imagined, of Laurentian.

The recent progress of American stratigraphy has fully justified the views of the second named and older school, that of Eaton. It has been shown that the First or Transition Graywacke of this author, which was the Upper Taconic of Emmons, and includes the primordial or Cambrian fauna, rests in unconformable stratification upon the various crystalline series named, and that all of these great groups belong to Eozoic time. The Quebec group of Logan, as well as what he called the Potsdam group, is this same Cambrian or Transition Graywacke. The Hudson River group also, as first described by Vanuxem and by Mather, and, later, by Logan up to 1860 (when he proposed for it the name of the Quebec group) is nothing else than this same Cambrian Graywacke, with the addition, in certain localities, of a portion of Laconian, and in others of schistose beds containing the second fauna (Utica and Loraine shales). The above explanation becomes necessary for the reason that the Canadian geologists

(Logan and the present writer) formerly described, in accordance with the views of the first-named school, certain crystalline schists chiefly Huronian, as altered rocks of the Hudson River group, and later (from 1860 to 1867) as of the Quebec group.

The cupriferous series of the basin of Lake Superior (the distinctness of which was maintained by the writer in 1873, when he called it the Keweenaw group, a name which he subsequently changed to Keweenian), which has a thickness probably greatly exceeding 20,000 feet, was also by Logan referred to the Quebec group. It has, however, been shown by later observers that the fossiliferous sandstones which rest in horizontal layers upon the inclined strata of the Keweenian, belong to the Cambrian, and hold the fauna of the Potsdam. The conglomerates of the Keweenian cupriferous series contain portions alike of Laurentian Arvonian, Huronian and Montalban rocks, and appear, according to the latest observations, to overlie the schists which we have referred to the Taconian. The sandstones and argillites of the Keweenian, which are interstratified with great masses of melaphyre, are uncrystalline. It remains to be determined whether the intermediate Keweenian series has greater affinities with the Taconian than with the Cambrian.

We have thus sought to include provisionally the whole vast system of Primitive and Transition crystalline rocks, from the fundamental granitoid gneiss upward, under the names of Laurentian, Norian, Arvonian, Huronian, Montalban and Taconian, The Arvonian or petrosilex group intervenes between the Laurentian and the Huronian, but the peculiar characters of the Norian, and its localization to some few limited areas in Europe and North America, make it difficult for us, as yet, to define its precise relations to the Arvonian. The Norian however, probably, like the Arvonian, occupies a horizon between Laurentian and Huronian. Much time may pass, and many stratigraphical studies must be made before the precise relations of the Huronian and the succeeding Montalban can be defined. It seems probable in the present state of our knowledge that the Montalban series was, in many cases, deposited over areas where the Huronian had never been laid down. Notwithstanding the great geographical extent, and the importance of these two series, neither can claim that universality which probably belonged to the primitive

granitic substratum, a universality soon interrupted by the appearance of dry land, which preceded Huronian time.

V. Address before the British Association.

Montreal, August 27, 1884.

By the Right Hon. Lord Rayleigh, M.A., D.C.L., F.R.S., President.

Ladies and Gentlemen,—It is no ordinary meeting of the British Association which I have now the honor of addressing. For more than fifty years the Association has held its autumn gathering in various towns of the United Kingdom, and within those limits there is, I suppose, no place of importance which we have not visited. And now, not satisfied with past successes, we are seeking new worlds to conquer. When it was first proposed to visit Canada, there were some who viewed the project with hesitation. For my own part I never quite understood the grounds of their apprehension. Perhaps they feared the thin edge of the wedge. When once the principle was admitted, there was no knowing to what it might lead. So rapid is the development of the British empire, that the time might come when a visit to such out-of-the-way places as London or Manchester could no longer be claimed as a right, but only asked for as a concession to the susceptibilities of the English. But, seriously, whatever objections may have at first been felt soon were outweighed by the consideration of the magnificent opportunities which your hospitality affords of extending the sphere of our influence and of becoming acquainted with a part of the Queen's dominions which, associated with splendid memories of the past, is advancing daily, by leaps and bounds, to a position of importance such as not long ago was scarcely dreamed of. For myself, I am not a stranger to your shores. I remember well the impression made upon me, seventeen years ago, by the wild rapids of the St. Lawrence, and the gloomy grandeur of the Saguenay. If anything impressed me more, it was the kindness with which I was received by yourselves, and which I doubt not will be again extended, not merely to myself but to all the English members of the Association. I am confident that those who have made up their minds to cross the ocean will not repent their decision, and that, apart altogether from scientific interests, great advantage may be expected from

this visit. We Englishmen ought to know more than we do of matters relating to the colonies, and anything which tends to bring the various parts of the empire into closer contact can hardly be overvalued. It is pleasant to think that this Association is the means of furthering an object which should be dear to the hearts of all of us; and I venture to say that a large proportion of the visitors to this country will be astonished by what they see, and will carry home an impression which time will not readily efface.

To be connected with this meeting is, to me, a great honour, but also a great responsibility. In one respect, especially, I feel that the Association might have done well to choose another President. My own tastes have led me to study mathematics and physics rather than geology and biology, to which naturally more attention turns in a new country, presenting, as it does, a fresh field for investigation. A chronicle of achievements in these departments by workers from among yourselves would have been suitable to the occasion, but could not come from me. If you would have preferred a different subject for this address, I hope, at least, that you will not hold me entirely responsible.

At annual gatherings like ours, the pleasure with which friends meet friends again is sadly marred by the absence of those who can never more take their part in our proceedings. Last year my predecessor in this office had to lament the untimely loss of Spottiswoode and Henry Smith, dear friends of many of us, and prominent members of our Association. And now again, a well-known form is missing. For many years Sir W. Siemens has been a regular attendant at our meetings, and to few, indeed, have they been more indebted for success. Whatever the occasion, in his presidential address of two years ago, or in communications to the Physical and Mechanical Sections, he had always new and interesting ideas, put forward in language which a child could understand, so great a master was he of the art of lucid statement in his adopted tongue. "Practice with Science" was his motto. Deeply engaged in industry, and conversant, all his life, with engineering operations, his opinion was never that of a mere theorist. On the other hand, he abhorred rule of thumb, striving always to master the scientific principles which underlie rational design and invention.

It is not necessary that I should review in detail the work of Siemens. The part which he took, during recent years, in the development of the dynamo machine must be known to many of you. We owe to him the practical adoption of the method, first suggested by Wheatstone, of throwing into a shunt the coils of the field magnets, by which a greatly improved steadiness of action is obtained. The same characteristics are observable throughout—a definite object in view and a well directed perseverance in overcoming the difficulties by which the path is usually obstructed.

These are, indeed, the conditions of successful invention. The world knows little of such things, and regards the new machine or the new method as the immediate outcome of a happy idea. Probably, if the truth were known, we should see that, in nine cases out of ten, success depends as much upon good judgment and perseverance as upon fertility of imagination. The labors of our great inventors are not unappreciated, but I doubt whether we adequately realize the enormous obligations under which we lie. It is no exaggeration to say that the life of such a man as Siemens is spent in the public service; the advantages which he reaps for himself being as nothing in comparison with those which he confers upon the community at large.

As an example of this it will be sufficient to mention one of the most valuable achievements of his active life—his introduction, in conjunction with his brother, of the regenerative gas furnace, by which an immense economy of fuel (estimated at millions of tons annually) has been effected in the manufacture of steel and glass. The nature of this economy is easily explained. Whatever may be the work to be done by the burning of fuel, a certain temperature is necessary. For example, no amount of heat in the form of boiling water, would be of any avail for the fusion of steel. When the products of combustion are cooled down to the point in question, the heat which they still contain is useless as regards the purpose in view. The importance of this consideration depends entirely upon the working-temperature. If the object be the evaporation of water or the warming of a house, almost all the heat may be extracted from the fuel without special arrangements. But it is otherwise when the temperature required is not much below that of combustion itself, for then the

escaping gases carry away with them the larger part of the whole heat developed. It was to meet this difficulty that the regenerative furnace was devised. The products of combustion, before dismissal into the chimney, are caused to pass through piles of loosely stacked fire-brick, to which they give up their heat. After a time the fire-brick upon which the gases first impinge, becomes nearly as hot as the furnace itself. By suitable valves the burnt gases are then diverted through another stack of brickwork, which they heat up in like manner, while the heat stored up in the first stack is utilized to warm the unburnt gas and air on their way to the furnace. In this way almost all the heat developed at a high temperature during the combustion is made available for the work in hand.

As it is now several years since your presidential chair has been occupied by a professed physicist, it may naturally be expected that I should attempt some record of recent progress in that branch of science, if indeed such a term be applicable. For it is one of the difficulties of the task that subjects as distinct as Mechanics, Electricity, Heat, Optics and Acoustics, to say nothing of Astronomy and Meteorology, are included under Physics. Any one of these may well occupy the life-long attention of a man of science, and to be thoroughly conversant with all of them is more than can be expected of any one individual, and is probably incompatible with the devotion of much time and energy to the actual advancement of knowledge. Not that I would complain of the association sanctioned by common parlance; a sound knowledge of at least the principles of general Physics is necessary to the cultivation of any department. The prodominance of the sense of sight, as the medium of communication with the outer world, brings with it dependence upon the science of Optics; and there is hardly a branch of science in which the effects of temperature have not (often without much success) to be reckoned with. Besides, the neglected borderland between two branches of knowledge is often that which best repays cultivation; or, to use a metaphor of Maxwell's, the greatest benefits may be derived from a cross fertilization of the sciences. The wealth of materia is an evil only from the point of view of one of whom too much may be expected. Another difficulty incident to the task, which must be faced but cannot be overcome, is that of estimating

rightly the value, and even the correctness of recent work. It is not always that which seems at first the most important that proves in the end to be so. The history of science teems with examples of discoveries which attracted little notice at the time, but afterwards have taken root downwards and borne much fruit upwards.

One of the most striking advances of recent years is in the production and application of electricity upon a large scale—a subject to which I have already had occasion to allude in connection with the work of Sir W. Siemens. The dynamo machine is indeed founded upon discoveries of Faraday, now more than half a century old; but it has required the protracted labors of many inventors to bring it to its present high degree of efficiency. Looking back at the matter, it seems strange that progress should have been so slow. I do not refer to details of design, the elaboation of which must always, I suppose, require the experience of actual work to indicate what parts are structually weaker than they should be, or are exposed to undue wear and tear. But with regard to the main features of the problem, it would almost seem as if the difficulty lay in want of faith. Long ago it was recognized that electricity derived from chemical action is (on a large scale) too expensive a source of mechanical power, notwithstanding the fact that (as proved by Joule in 1846) the conversion of electrical into mechanical work can be effected with great economy. From this it is an evident consequence that electricity may advantageously be obained from mechanical power; and one cannot help thinking that if the fact had been borne steadily in mind, the development of the dynamo might have been much more rapid. But discoveries and inventions are apt to appear obvious when regarded from the standpoint of accomplished fact; and I draw attention to the matter only to point the moral that we do well to push the attack persistently when we can be sure beforehand that the obstacles to be overcome are only difficulties of contrivance, and that we are not vainly fighting unawares against a law of Nature.

The present development of electricity on a large scale depends, however, almost as much upon the incandescent lamp as upon the dynamo. The success of these lamps demands a very perfect vacuum—not more than about one millionth of the normal

quantity of air should remain—and it is interesting to recall that, twenty years ago, such vacua were rare even in the laboratory of the physicist. It is pretty safe to say that these wonderful results would never have been accomplished had practical applications alone been in view. The way was prepared by an army of scientific men whose main object was the advancement of knowledge, and who could scarcely have imagined that the processes which they elaborated would soon be in use on a commercial scale and entrusted to the hands of ordinary workmen.

When I speak in hopeful language of practical electricity, I do not forget the disappointment within the last year or two of many over sanguine expectations. The enthusiasm of the inventor and promotor are necessary to progress, and it seems to be almost a law of nature that it should overpass the bounds marked out by reason and experience. What is most to be regretted is the advantage taken by speculators of the often uninstructed interest felt by the public in novel schemes by which its imagination is fired. But looking forward to the future of electric lighting, we have good ground for encouragement. Already the lighting of large passenger ships is an assured success, and one which will be highly appreciated by those travellers who have experienced the tedium of long winter evenings unrelieved by adequate illumination. Here, no doubt, the conditions are in many respects especially favorable. As regards space, life on board ship is highly concentrated, while unity of management and the presence on the spot of skilled engineers obviate some of the difficulties that are met with under other circumstances. At present we have no experience of a house-to-house system of illumination on a great scale and in competition with cheap gas; but preparations are already far advanced for trial on an adequate scale in London. In large institutions, such as theatres and factories, we all know that electricity is in successful and daily extending operation.

When the necessary power can be obtained from the fall of water instead of from the combustion of coal, the conditions of the problem are far more favorable. Possibly the severity of your winters may prove an obstacle, but it is impossible to regard your splendid river without the thought arising that the day may come when the vast powers now running to waste shall be bent into your service. Such a project demands of course the most

careful consideration, but it is one worthy of an intelligent and enterprising community.

The requirements of practice react in the most healthy manner upon scientific electricity. Just as in former days the science received a stimulus from the application to telegraphy, under which everything relating to measurement on a small scale acquired an importance and development for which we might otherwise have had long to wait, so now the requirements of electric lighting are giving rise to a new development of the art of measurement upon a large scale, which cannot fail to prove of scientific as well as practical importance. Mere change of scale may not at first appear a very important matter, but it is surprising how much modification it entails in the instruments, and in the processes of measurement. For instance, the resistance coils on which the electrician relies in dealing with currents whose maximum is a fraction of an ampere, fail altogether when it becomes a question of hundreds, not to say thousands, of ampers.

The powerful currents, which are now at command, constitute almost a new weapon in the hands of the physicist. Effects, which in old days were rare and difficult of observation, may now be produced at will on the most conspicuous scale. Consider for a moment Faraday's great discovery of the "Magnetization of Light," which Tyndall likens to the Weisshorn among mountains, as high, beautiful, and alone. This judgment (in which I fully concur) relates to the scientific aspect of the discovery, for to the eye of sense nothing could have been more insignificant. It is even possible that it might have eluded altogether the penetration of Faraday, had he not been provided with a special quality of very heavy glass. At the present day these effects may be produced upon a scale that would have delighted their discoverer, a rotation of the plane of polarization through 180° being perfectly feasible. With the aid of modern appliances Kundt and Röntgen in Germany, and H. Becquerel in France, have detected the rotation in gases and vapours, where, on account of its extreme smallness, it had previously escaped notice.

Again, the question of the magnetic saturation of iron has now an importance entirely beyond what it possessed at the time of Joule's early observations. Then it required special arrangements purposely contrived to bring it into prominence. Now in every

dynamo machine, the iron of the field-magnets approaches a state of saturation, and the very elements of an explanation of the action require us to take the fact into account. It is indeed probable that a better knowledge of this subject might lead to improvements in the design of these machines.

Notwithstanding the important work of Rowland and Stoletow, the whole theory of the behaviour of soft iron under varying magnetic conditions is still somewhat obscure. Much may be hoped from the induction-balance of Hughes, by which the marvellous powers of the telephone are applied to the discrimination of the properties of metals as regards magnetism and electric conductivity.

The introduction of powerful alternate currents, in machines by Siemens, Gordon, Ferranti, and others, is likely also to have a salutary effect in educating those so-called practical electricians whose ideas do not easily rise above ohms and volts. It has long been known that when the changes are sufficiently rapid, the phenomena are governed much more by induction, or electric inertia, than by mere resistance. On this principle much may be explained that would otherwise seem paradoxical. To take a comparatively simple case, conceive an electro-magnet wound with two contiguous wires, upon which acts a given rapidly periodic electro-motive force. If one wire only be used, a certain amount of heat is developed in the circuit. Suppose now that the second wire is brought into operation in parallel—a proceeding equivalent to doubling the section of the original wire. An electrician accustomed only to constant currents would be sure to think that the heating effect would be doubled by the change, as much heat being developed in each wire separately as was at first in the single wire. But such a conclusion would be entirely erroneous. The total current, being governed practically by self-induction of the circuit, would not be augmented by the accession of the second wire, and the total heating effect, so far from being doubled, would, in virtue of the superior conductivity, be halved.

During the last few years much interest has been felt in the reduction to an absolute standard of measurements of electromotive force, current, resistance, etc., and to this end many laborious investigations have been undertaken. The subject is one that has engaged a good deal of my own attention, and I

should naturally have felt inclined to dilate upon it, but that I feel it to be too abstruse and special to be dealt with in detail upon an occasion like the present. As regards resistance, I will merely remind you that the recent determinations have shown a so greatly improved agreement, that the Conference of Electricians assembled at Paris, in May, felt themselves justified in defining the ohm for practical use as the resistance of column of mercury of 0 ° C., one square millimetre in section, and 106 centmetres in length—a definition differing by a little more than one per cent. from that arrived at twenty years ago by a committee of this Association.

A standard of resistance once determined upon can be embodied in a "resistance coil," and copied without much trouble, and with great accuracy. But in order to complete the electrical system, a second standard of some kind is necessary, and this is not so easily embodied in a permanent form. It might conveniently consist of a standard galvanic cell capable of being prepared in a definite manner, whose electro-motive force is once for all determined. Unfortunately, most of the batteries in ordinary use are for one reason or another unsuitable for this purpose, but the cell introduced by Mr. Latimer Clark, in which the metals are zinc in contact with saturated zinc-sulphate and pure mercury in contact with mercurous sulphate, appears to give satisfactory results. According to my measurements, the electro-motive force of this cell is 1,435 theoretical volts.

We may also conveniently express the second absolute electrical measurement necessary to the completion of the system by taking advantage of Faraday's law that the quantity of metal decomposed in an electrolytic cell is proportional to the whole quantity of electricity that passes. The best metal for the purpose is silver deposited from a solution of the nitrate or of the chlorate. The results recently obtained by Professor Kohlrausch and by myself are in very good agreement, and the conclusion that one ampere flowing for one hour decomposes 4.025 grains of silver, can hardly be in error by more then a thousandth part. This number being known, the silver-voltameter gives a ready and very accurate method of measuring currents of intensity, varying from 1-10 ampere to four or five amperes.

The beautiful and mysterious phenomena attending the

discharge of electricity in nearly vacuous spaces have been investigated and in some degree explained by De la Rue, Crookes, Shuster, Moulton, and the lamented Spottiswoode, as well as by various able foreign experimenters. In a recent research Crookes has sought the origin of a bright citron-colored band in the phosphorescent spectrum of certain earths, and, after encountering difficulties and anomalies of a most bewildering kind, has succeeded in proving that it is due to yttrium, an element much more widely distributed than had been supposed. A conclusion like this is stated in a few words, but those only who have undergone similar experience are likely to appreciate the skill and perseverance of which it is the final reward.

A remarkable observation by Hall of Baltimore, from which it appeared that the flow of electricity in a conducting sheet was disturbed by magnetic force, has been the subject of much discussion. Mr. Shelford Bidwell has brought forward experiments tending to prove that the effect is of a secondary character, due in the first instance to the mechanical force operating upon the conductor of an electric current when situated in a powerful magnetic field. Mr. Bidwell's view agrees, in the main, with Mr. Hall's division of the metals into two groups according to the direction of the effect.

Without doubt the most important achievement of the older generation of scientific men has been the establishment and application of the great laws of Thermo-dynamics, or, as it is often called, the Mechanical Theory of Heat. The first law, which asserts that heat and mechanical work can be transformed one into the other at a certain fixed rate, is now well understood by every student of physics, and the number expressing the mechanical equivalent of heat resulting from the experiments of Joule, has been confirmed by the researches of others, and especially of Rowland. But the second law, which practically is even more important than the first, is only now beginning to receive the full appreciation due to it. One reason of this may be found in a not unnatural confusion of ideas. Words do not always lend themselves readily to the demands that are made upon them by a growing science, and I think that the almost unavoidable use of the word "equivalent" in the statement of the first law is partly responsible for the little attention that is given to the second.

For the second law so far contradicts the usual statement of the first, as to assert that equivalents of heat and work are not of equal value. While work can always be converted into heat, heat can only be converted into work under certain limitations. For every practical purpose the work is worth the most, and when we speak of equivalents, we used the word in the same sort of special sense as that in which chemists speak of equivalents of gold and iron. The second law teaches us that the real value of heat, as a source of mechanical power, depends upon the temperature of the body in which it resides; the hotter the body in relation to its surroundings, the more available the heat.

In order to see the relations which obtain between the first and the second law of Thermo-dynamics, it is only necessary for us to glance at the theory of the steam-engine. Not many years ago calculations were plentiful, demonstrating the inefficiency of the steam-engine on the basis of a comparison of the work actually got out of the engine with the mechanical equivalent of the heat supplied to the boiler. Such calculations took into account only the first law of Thermo-dynamics, which deals with the equivalents of heat and work, and have very little bearing upon the practical question of efficiency, which requires us to have regard also to the second law. According to that law the fraction of the total energy which can be converted into work depends upon the relative temperatures of the boiler and condenser, and it is, therefore, manifest that, as the temperature of the boiler cannot be raised indefinitely, it is impossible to utilize all the energy which, according to the first law of Thermo-dynamics, is resident in the coal. On a sounder view of the matter, the efficiency of the steam-engine is found to be so high that there is no great margin remaining for improvement. The higher initial temperature possible in the gas-engine opens out much wider possibilities, and many good judges look forward to a time when the steam-engine will have to give way to its younger rival.

To return to the theoretical question, we may say with Sir W. Thompson, that, though energy cannot be destroyed, it ever tends to be dissipated, or to pass from more available to less available forms No one who has grasped this principle can fail to recognize its immense importance in the system of the Universe. Every change—chemical, thermal, or mechanical—which takes

or can take place in Nature does so at the cost of a certain amount of available energy. If, therefore, we wish to enquire whether or not a proposed transformation can take place, the question to be considered is whether its occurrence would involve dissipation of energy. If not, the transformation is (under the circumstances of the case) absolutely excluded. Some years ago, in a lecture at the Royal Institution, I endeavored to draw the attention of chemists to the importance of the principle of dissipation in relation to their science, pointing out the error of the usual assumption that a general criterion is to be found in respect of the development of heat. For example, the solution of a salt in water is, if I may be allowed the phrase, a downhill transformation. It involves dissipation of energy, and can therefore go forward; but in many cases it is associated with the absorption rather than with the development of heat. I am glad to take advantage of the present opportunity in order to repeat my recommendation, with an emphasis justified by actual achievement. The foundations laid by Thomson now bear an edifice of no mean proportions, thanks to the labors of several physicists, among whom must be especially mentioned Willard Gibbs and Helmholtz. The former has elaborated a theory of the equilibrium of heterogeneous substances, wide in its principles, and, we cannot doubt, far-reaching in its consequences. In a series of masterly papers Helmholtz has developed the conception of *free energy* with very important applications to the theory of the galvanic cell. He points out that the mere tendency to solution bears in some cases no small proportion to the affinities more usually reckoned chemical, and contributes largely to the total electro-motive force. Also in our own country Dr. Alder Wright has published some valuable experiments relating to the subject.

From the further study of electrolysis we may expect to gain improved views as to the nature of the chemical reactions, and of the forces concerned in bringing them about. I am not qualified —I wish I were—to speak to you on recent progress in general chemistry. Perhaps my feelings towards a first love may blind me, but I cannot help thinking that the next great advance, of which we have already some foreshadowing, will come on this side. And if I might without presumption venture a word of recommendation it would be in favor of a more minute study of the simpler chemical phenomena.

Under the head of scientific mechanics it is principally in relation to fluid motion that advances may be looked for. In speaking upon this subject I must limit myself almost entirely to experimental work. Theoretical hydro-dynamics, however important and interesting to the mathematician, are eminently unsuited to oral exposition. All I can do to attenuate an injustice, to which theorists are pretty well accustomed, is to refer you to the admirable reports of Mr. Hicks, published under the auspices of this Association.

The important and highly practical work of the late Mr Froude in relation to the propulsion of ships is doubtless known to most of you. Recognizing the fallacy of views then widely held as to the nature of the resistance to be overcome, he showed to demonstration that, in the case of fair-shaped bodies, we have to deal almost entirely with resistance dependent upon skin-friction and at high speeds upon the generation of surface-waves by which energy is carried off. At speeds which are moderate in relation to the size of the ship, the resistance is practically dependent upon skin-friction only. Although Professor Stokes and other mathematicians had previously published calculations pointing to the same conclusion, there can be no doubt that the view generally entertained was very different. At the first meeting of the Association which I ever attended, as an intelligent listener, at Bath, in 1864, I well remember the surprise which greeted a statement by Rankine that he regarded skin-friction as the only legitimate resistance to the progress of a well-designed ship. Mr. Froude's experiments have set the question at rest in a manner satisfactory to those who had little confidence in theoretical prevision.

In speaking of an explanation as satisfactory in which skin-friction is accepted as the cause of resistance, I must guard myself against being supposed to mean that the nature of skin-friction is itself well understood. Although its magnitude varies with the smoothness of the surface, we have no reason to think that it would disappear at any degree of smoothness consistent with an ultimate molecular structure. That it is connected with fluid viscosity is evident enough, but the *modus operandi* is still obscure.

Some important work bearing upon the subject has recently

been published by Professor O. Reynolds, who has investigated the flow of water in tubes as dependent upon the velocity of motion and upon the size of the bore. The laws of motion in capillary tubes, discovered experimentally by Poiseuille, are in complete harmony with theory. The resistance varies as the velocity, and depends in a direct manner upon the constant of viscosity. But when we come to the larger pipes and higher velocities with which engineers usually have to deal, the theory which presupposes a regularly stratified motion evidently ceases to be applicable, and the problem becomes essentially identical with that of skin-friction in relation to ship propulsion. Professor Reynolds has traced with much success the passage from the one state of things to the other, and has proved the applicability under these complicated conditions of the general laws of dynamical similarity as adapted to viscous fluids by Professor Stokes. In spite of the difficulties which beset both the theoretical and experimental treatment, we may hope to attain before long to a better understanding of a subject which is certainly second to none in scientific as well as practical interest.

As also closely connected with the mechanics of viscous fluids I must not forget to mention an important series of experiments upon the friction of oiled surfaces, recently executed by Mr. Tower for the Institution of Mechanical Engineers. The results go far towards upsetting some ideas hitherto widely admitted. When the lubrication is adequate the friction is found to be nearly independent of the load, and much smaller than is usually supposed, giving a coefficient as low as 1–1000. When a layer of oil is well formed the pressure between the solid surfaces is really borne by the fluid, and the work lost is spent in shearing, that is in causing one stratum of the oil to glide over another.

In order to maintain its position, the fluid must possess a certain degree of viscosity, proportionate to the pressure ; and even when this condition is satisfied it would appear to be necessary that the layer should be thicker on the ingoing than on the outgoing side. We may, I believe, expect from Professor Stokes a further elucidation of the processes involved. In the meantime, it is obvious that the results already obtained are of the utmost value, and fully justify the action of the Institution in devoting a part of its resources to experimental work. We may hope, indeed,

that the example thus wisely set may be followed by other public bodies associated with various departments of industry.

I can do little more than refer to the interesting observations of Professor Darwin, Mr. Hunt, and Mr. Forel on Ripplemark. The processes concerned would seem to be of a rather intricate character, and largely dependent upon fluid viscosity. It may be noted, indeed, that most of the still obscure phenomena of hydro-dynamics require for their elucidation a better comprehension of the laws of viscous motion. The subject is one which offers peculiar difficulties. In some problems in which I have lately been interested, a circulating motion presents itself of the kind which the mathematician excludes from the first when he is treating of fluids destitute altogether of viscosity. The intensity of this motion proves, however, to be independent of the coefficient of viscosity, so that it cannot be correctly dismissed from consideration as a consequence of a supposition that the viscosity is infinitely small. The apparent breach of continuity can be explained, but it shows how much care is needful in dealing with the subject, and how easy it is to fall into error.

The nature of gaseous viscosity, as due to the diffusion of momentum, has been made clear by the theoretical and experimental researches of Maxwell. A flat disc moving in its own plane between two parallel solid surfaces is impeded by the necessity of shearing the intervening layers of gas, and the magnitude of the hindrance is proportional to the velocity of the motion and to the viscosity of the gas, so that under similar circumstances this effect may be taken as a measure, or rather definition, of the viscosity. From the dynamical theory of gases, to the development of which he contributed so much, Maxwell drew the startling conclusion that the viscosity of a gas should be independent of its density,—that within wide limits the resistance to the moving disc should be scarcely diminished by pumping the gas, so as to form a partial vacuum. Experiment fully confirmed this theoretical anticipation—one of the most remarkable to be found in the whole history of science, and proved that the swinging disc was retarded by the gas as much when the barometer stood at half an inch as when it stood at thirty inches. It was obvious, of course, that the law must have a limit, that at a certain point of exhaustion the gas must begin to lose its power ; and I remem-

ber discussing with Maxwell, soon after the publication of his experiments, the whereabouts of the point at which the gas would cease to produce its ordinary effect. His apparatus, however, was quite unsuited for high degrees of exhaustion, and the failure of the law was first observed by Kundt and Warburg, as pressures below 1 mm. of mercury. Subsequently the matter has been thoroughly examined by Crookes, who extended his observations to the highest degrees of exhaustion as measured by MacLeod's gauge. Perhaps the most remarkable results relate to hydrogen. From the atmospheric pressure of 760 mm. down to about $\frac{1}{2}$ mm. of mercury the viscosity is sensibly constant. From this point to the highest vacua, in which less than one-millionth of the original gas remains, the coefficient of viscosity drops down gradually to a small fraction of its original value. In these vacua Mr. Crookes regards the gas as having assumed a different ultra-gaseous condition ; but we must remember that the phenomena have relation to the other circumstances of the case, especially the dimensions of the vessel, as well as to the condition of the gas.

Such an achievement as the prediction of Maxwell's law of viscosity has, of course, drawn increased attention to the dynamical theory of gases. The success which has attended the theory in the hands of Clausius, Maxwell, Boltzmann and other mathematicians, not only in relation to viscosity, but over a large part of the entire field of our knowledge of gases, proves that some of its fundamental postulates are in harmony with the reality of nature. At the same time it presents serious difficulties, and we cannot but feel that while the electrical and optical properties of gases remain out of relation to the theory, no final judgment is possible. The growth of experimental knowledge may be trusted to clear up many doubtful points, and a younger generation of theorists will bring to bear improved mathematical weapons. In the meantime we may fairly congratulate ourselves on the possession of a guide which has already conducted us to a position which could hardly otherwise have been attained.

In optics attention has naturally centred upon the spectrum. The mystery attaching to the invisible rays lying beyond the red has been fathomed to an extent that a few years ago would have seemed almost impossible. By the use of special photographic methods Abney has mapped out the peculiarities of this region

with such success that our knowledge of it begins to be comparable with that of the parts visible to the eye. Equally important work has been done by Langley, using a refined invention of his own based upon the principle of Siemens' pyrometer. This instrument measures the actual energy of the radiation, and thus expresses the effects of various parts of the spectrum upon a common scale, independent of the properties of the eye and of sensitive photographic preparations. Interesting results have also been obtained by Becquerel, whose method is founded upon a curious action of the ultra-red rays in enfeebling the light emitted by phosphorescent substances. One of the most startling of Langley's conclusions relates to the influence of the atmosphere in modifying the quality of solar light. By the comparison of observations made through varying thicknesses of air, he shows that the atmospheric absorption tells most upon the light of high refrangibility; so that, to an eye situated outside the atmosphere, the sun would present a decidedly bluish tint. It would be interesting to compare the experimental numbers with the law of scattering of light by small particles, given some years ago as the result of theory. The demonstration by Langley of the inadequacy of Cauchy's law of dispersion to represent the relation between the refrangibility and wave-length in the lower part of the spectrum must have an important bearing upon optical theory.

The investigation of the relation of the visible and ultra-violet spectrum to various forms of matter has occupied the attention of a host of able workers, among whom none have been more successful than my colleagues at Cambridge, Professors Liveing and Dewar. The subject is too large both for the occasion and for the individual, and I must pass it by. But, as more closely related to optics proper, I cannot resist recalling to your notice a beautiful application of the idea of Doppler to the discrimination of the origin of certain lines observed in the solar spectrum. If a vibrating body have a general motion of approach or recession the waves emitted from it reach the observer with a frequency which in the first case exceeds, and in the second case falls short of, the real frequency of the vibrations themselves. The consequence is that, if a glowing gas be in motion in the line of sight, the spectral lines are thereby displaced from the position that they would occupy were the gas at rest—a principle which, in the

hands of Huggins and others, has led to a determination of the motion of certain fixed stars relatively to the solar system. But the sun is itself in rotation, and thus the position of a solar spectral line is slightly different according as the light comes from advancing or from the retreating limb. This displacement was, I believe, first observed by Thollon : but what I desire now to draw attention to is the application of it by Cornu to determine whether a line is of solar or atmospheric origin. For this purpose a small image of the sun is thrown upon the slit of the spectroscope, and caused to vibrate two or three times a second, in such a manner that the light entering the instrument comes alternately from the advancing and retreating limbs. Under these circumstances a line due to absorption within the sun appears to tremble, as the result of slight alternately opposite displacements. But if the seat of the absorption be in the atmosphere it is a matter of indifference from what part of the sun the light originally proceeds, and the line maintains its position in spite of the oscillation of the image upon the slit of the spectroscope. In this way Cornu was able to make a discrimination which can only otherwise be effected by a difficult comparison of appearances under various solar altitudes.

The instrumental weapon of investigation, the spectroscope itself, has made important advances on the theoretical side. We have for our guidance the law that the optical power in gratings is proportional to the total number of lines accurately ruled, without regard to the degree of closeness, and in prisms that it is proportional to the thickness of glass traversed. The magnificent gratings of Rowland are a new power in the hands of the spectroscopist, and as triumphs of mechanical art seem to be little short of perfection. In our own report for 1882 Mr. Mallock has described a machine constructed by him, for ruling large diffraction-gratings, similar in some respects to that of Rowland.

The great optical constant, the velocity of light, has been the subject of three distinct investigations by Cornu, Michelson, and Forbes. As may be supposed, the matter is of no ordinary difficulty, and it is therefore not surprising that the agreement should be less decided than could be wished. From their observations, which were made by a modification of Fizeau's method of the toothed wheel, Young and Forbes drew the conclusion that

the velocity of light *in vacuo* varies from color to color, to such an extent that the velocity of blue light is nearly two per cent. greater than that of red light. Such a variation is quite opposed to existing theoretical notions, and could only be accepted on the strongest evidence. Mr. Michelson, whose method (that of Foucault) is well suited to bring into prominence a variation of velocity with wave-length, informs me that he has recently repeated his experiments, with special reference to the point in question, and has arrived at the conclusion that no variation exists comparable with that asserted by Young and Forbes. The actual velocity differs little from that found from his first series of experiments, and may be taken to be 299,800 kilometres per second.

It is remarkable how many of the playthings of our childhood give rise to questions of the deepest scientific interest. The top is or may be understood, but a complete comprehension of the kite and of the soap-bubble would carry us far beyond our present stage of knowledge. In spite of the admirable investigations of Plateau, it still remains a mystery why soapy water stands almost alone among fluids as a material for bubbles. The beautiful development of color was long ago ascribed to the interference of light, called into play by the gradual thinning of the film. In accordance with this view the tint is determined solely by the thickness of the film and the refractive index of the fluid. Some of the phenomena are however so curious as to have led excellent observers, like Brewster, to reject the theory of thin plates, and to assume the secretion of various kinds of coloring matter. If the rim of a wine-glass be dipped in soapy water, and then held in a vertical position, horizontal bands soon begin to show at the top of the film, and extend themselves gradually, downwards. According to Brewster these bands are not formed by the "subsidence and gradual thinning of the film," because they maintain their horizontal position when the glass is turned round its axis. The experiment is both easy and interesting; but the conclusion drawn from it cannot be accepted. The fact is that the various parts of the film cannot quickly alter their thickness, and hence when the glass is rotated they re-arrange themselves in order of superficial density, the thinner parts floating up over, or through the thicker parts. Only thus can the tendency be satisfied the centre of gravity to assume the lowest possible position.

When the thickness of a film falls below a small fraction of the length of a wave of light, the color disappears and is replaced by an intense blackness. Professors Reinold and Rücker have recently made the remarkable observation that the whole of the black region soon after its formation is of uniform thickness, the passage from the black to the colored portions being exceedingly abrupt. By two independent methods they have determined the thickness of the black film to lie between seven and fourteen millionths of a millimetre; so that the thinnest films correspond to about one-seventieth of a wave-length of light. The importance of these results in regard to molecular theory is too obvious to be insisted upon.

The beautiful inventions of the telephone and the phonograph, although in the main dependent upon principles long since established, have imparted a new interest to the study of acoustics. The former, apart from its uses in every-day life, has become in the hands of its inventor, Graham Bell, and of Hughes, an instrument of first-class scientific importance. The theory of its action is still in some respects obscure, as is shown by the comparative failure of the many attempts to improve it. In connection with some explanations that have been offered, we do well to remember that molecular change in solid masses are inaudible in themselves, and can only be manifested to our ears by the generation of a to-and-fro motion of the external surface extending over a sensible area. If the surface of a solid remains undisturbed, our ears can tell us nothing of what goes on in the interior.

In theoretical acoustics progress has been steadily maintained, and many phenomena which were obscure twenty or thirty years ago have since received adequate explanation. If some important practical questions remain unsolved, one reason is that they have not yet been definitely stated. Almost everything in connection with the ordinary use of our senses presents peculiar difficulties to scientific investigation. Some kinds of information with regard to their surroundings are of such paramount importance to successive generations of living beings, that they have learned to interpret indications which, from a physical point of view, are of the slenderest character. Every day we are in the habit of recognising, without much difficulty, the quarter from which a sound proceeds, but by what steps we attain that end has not yet been

satisfactorily explained. It has been proved that when proper precautions are taken we are unable to distinguish whether a pure tone (as from a vibrating tuning-fork held over a suitable resonator) comes to us from in front or from behind. This is what might have been expected from an *a priori* point of view; but what would not have been expected is that with almost any other sort of sound, from a clap of the hands to the clearest vowel sound, the discrimination is not only possible but easy and instinctive. In these cases it does not appear how the possession of two ears helps us, though there is some evidence that it does; and even when sounds come to us from the right or left, the explanation of the ready discrimination which is then possible with pure tone is not so easy as might at first appear. We should be inclined to think that the sound was heard much more loudly with the ear that is turned towards than with the ear that is turned from it, and that in this way the direction was recognized. But if we try the experiment, we find that, at any rate with notes near the middle of the musical scale, the difference of loudness is by no means so very great. The wave-lengths of such notes are long enough in relation to the dimensions of the head to forbid the formation of anything like a sound-shadow in which the averted ear might be sheltered.

In concluding this imperfect survey of recent progress in physics, I must warn you emphatically that much of great importance has been passed over altogether. I should have liked to speak to you of those far-reaching speculations, especially associated with the name of Maxwell in which light is regarded as a disturbance in an electro-magnetic medium. Indeed at one time I had thought of taking the scientific work of Maxwell as the principal theme of this address. But, like most men of genius, Maxwell delighted in questions too obscure and difficult for hasty treatment, and thus much of his work could hardly be considered upon such an occasion as the present. His biography has recently been published, and should be read by all who are interested in science and in scientific men. His many-sided character, the quaintness of his humor, the penetration of his intellect, his simple but deep religious feeling, the affection between son and father, the devotion of husband to wife, all combine to form a rare and fascinating picture. To estimate rightly his influence

upon the present state of science, we must regard not only the work that he executed himself, important as that was, but also the ideas and the spirit which he communicated to others. Speaking for myself, as one who in a special sense entered into his labors, I should find it difficult to express adequately my feeling of obligation. The impress of his thoughts may be recognized in much of the best work of the present time. As a teacher and examiner, he was well acquainted with the almost universal tendency of uninstructed minds to elevate phrases above things ; to refer, for example, to the principle of the conservation of energy for an explanation of the persistent rotation of a fly-wheel, almost in the style of the doctor in " La Malade Imaginaire," who explains the facts that opium sends you to sleep by its soporific virtue. Maxwell's endeavor was always to keep the facts in the foreground, and to his influence, in conjunction with that of Thomson and Helmholtz, is largely due that elimination of unnecessary hypothesis, which is one of the distinguishing characteristics of the science of the present day.

In speaking unfavorably of superfluous hypothesis, let me not be misunderstood. Science is nothing without generalizations. Detached and ill-assorted facts are only raw material, and, in the absence of a theoretical solvent, have but little nutritive value. At the present time, and in some departments, the accumulation of material is so rapid that there is danger of indigestion. By a fiction as remarkable as any to be found in law, what has once been published, even though it be in the Russian language, is usually spoken of as " known," and it is often forgotten that the re-discovery in the library may be a more difficult and uncertain process than the first discovery in the laboratory. In this matter we are greatly dependent upon annual reports and abstracts, issued principally in Germany, without which the search for the discoveries of a little-known author would be well-nigh hopeless. Much useful work has been done in this direction in connection with our Association. Such critical reports as those upon Hydrodynamics, upon Tides and upon Spectroscopy, guide the investigator to the points most requiring attention, and in discussing past achievements contribute in no small degree to future progress. But though good work has been done, much yet remains to do.

If, as is sometimes supposed, science consisted in nothing but

the laborious accumulation of facts, it would soon come to a standstill, crushed, as it were, under its own weight. The suggestion of a new idea or the detection of a law, supersedes much that had previously been a burden upon the memory, and, by introducing order and coherence, facilitates the retention of the remainder in an available form. Those who are acquainted with the writings of the older electricians will understand my meaning when I instance the discovery of Ohm's law as a step by which the science was rendered easier to understand and to remember. Two processes are thus at work side by side, the reception of new material and the digestion and assimilation of the old; and as both are essential we may spare ourselves the discussion of their relative importance. One remark, however, should be made. The work which deserves, but I am afraid does not always receive, the most credit, is that in which discovery and explanation go hand in hand, in which not only are new facts presented, but their relations to old ones is pointed out.

In making ourselves acquainted with what has been done in any subject, it is good policy to consult first the writers of highest general reputation. Although in scientific matters we should aim at independent judgment, and not rely too much upon authority, it remains true that a good deal must often be taken upon trust. Occasionally an observation is so simple and easily repeated, that it scarcely matters from whom it proceeds; but as a rule it can hardly carry full weight when put forward by a novice whose care and judgment there has been no opportunity of testing, and whose irresponsibility may tempt him to "take shots," as it is called. Those who have had experience in accurate work know how easy it would be to save time and trouble by omitting precautions and passing over discrepancies, and yet, even without dishonest intention, to convey the impression of conscientious attention to details. Although the most careful and experienced cannot hope to escape occasional mistakes, the effective value of this kind of work depends much upon the reputation of the individual responsible for it.

In estimating the present position and prospects of experimental science, there is good ground for encouragement. The multiplication of laboratories gives to the younger generation opportunities such as have never existed before, and which excite the envy of those who have had to learn in middle life much that now forms

part of an undergraduate course. As to the management of such institutions there is room for a healthy difference of opinion. For many kinds of original work, especially in connection with accurate measurement, there is need of expensive apparatus; and it is often difficult to persuade a student to do his best with imperfect appliances when he knows that by other means a better result could be attained with greater facility. Nevertheless it seems to me important to discourage too great reliance upon the instrument-maker. Much of the best original work has been done with the homeliest appliances; and the endeavor to turn to the best account the means that may be at hand develops ingenuity and resource more than the most elaborate determinations with ready-made instruments. There is danger otherwise that the experimental education of a plodding student should be too mechanical and artificial, so that he is puzzled by small changes of apparatus, much as many school-boys are puzzled by a transposition of the letters in a diagram of Euclid.

From the general spread of a more scientific education, we are warranted in expecting important results. Just as there are some brilliant literary men with an inability, or at least a distaste practically amounting to inability, for scientific ideas, so there are a few with scientific tastes whose imaginations are never touched by merely literary studies. To save these from intellectual stagnation during several important years of their lives is something gained, but the thorough-going advocates of scientific education aim at much more. To them it appears strange, and almost monstrous, that the dead languages should hold the place they do in general education; and it can hardly be denied that their supremacy is the result of routine rather than of argument. I do not myself, take up the extreme position. I doubt whether an exclusively scientific training would be satisfactory; and where there is plenty of time and a literary aptitude I can believe that Latin and Greek may make a good foundation. But it is useless to discuss the question upon the supposition that the majority of boys attain either to a knowledge of the languages or to an appreciation of the writings of the ancient authors. The contrary is notoriously the truth; and the defenders of the existing system usually take their stand upon the excellence of its discipline. From this point of view there is something to be said. The laziest boy

must exert himself a little in puzzling out a sentence with grammar and dictionary, while instruction and supervision are easy to organize and not too costly. But when the case is stated plainly, few will agree that we can afford so entirely to disregard results. In after-life the intellectual energies are usually engrossed with business, and no further opportunity is found for attacking the difficulties which block the gateways of knowledge. Mathematics, especially if not learned young, are likely to remain unlearned. I will not further insist upon the educational importance of mathematics and science, because with respect to them I shall probably be supposed to be prejudiced. But of modern languages I am ignorant enough to give value to my advocacy. I believe that French and German, if properly taught, which I admit they rarely are at present, would go far to replace Latin and Greek from a disciplinary point of view, while the actual value of the acquisition would, in the majority of cases, be incomparably greater. In half the time usually devoted, without success, to the classical languages, most boys could acquire a really serviceable knowledge of French and German. History, and the serious study of English literature, now shamefully neglected, would also find a place in such a scheme.

There is one objection often felt to a modernized education as to which a word may not be without use. Many excellent people are afraid of science as tending towards materialism. That such apprehension should exist is not surprising, for, unfortunately, there are writers speaking in the name of science, who have set themselves to foster it, It is true that among scientific men, as in other classes, crude views are to be met with as to the deeper things of Nature; but that the life-long beliefs of Newton, of Faraday and of Maxwell are inconsistent with the scientific habit of mind, is surely a proposition which I need not pause to refute. It would be easy, however, to lay too much stress upon the opinions of even such distinguished workers as these. Men who devote their lives to investigation cultivate a love of truth for its own sake, and endeavor instinctively to clear up, and not, as is too often the object in business and politics, to obscure, a difficult question. So far the opinion of a scientific worker may have a special value; but I do not think that he has a claim, superior to that of other educated men, to assume the attitude of a prophet.

In his heart he knows that underneath the theories that he constructs there lie contradictions which he cannot reconcile. The higher mysteries of being, if penetrable at all by human intellect, require other weapons than those of calculation and experiment.

Without encroaching upon grounds appertaining to the theologian and the philosopher, the domain of natural science is surely broad enough to satisfy the wildest ambition of its devotees. In other departments of human life and interest, true progress is rather an article of faith than a rational belief; but in science a retrograde movement is, from the nature of the case, almost impossible. Increasing knowledge brings with it increasing power, and great as are the triumphs of the present century, we may well believe that they are but a foretaste of what discovery and invention have yet in store for mankind. Encouraged by the thought that our labors cannot be thrown away, let us redouble our efforts in the noble struggle. In the Old World and in the New, recruits must be enlisted to fill the place of those whose work is done. Happy should I be if, through this visit of the Association, or by any words of mine, a large measure of the youthful activity of the West could be drawn into this service. The work may be hard, and the discipline severe; but the interest never fails, and great is the privilege of achievement.

VI. The Development Theory: A Review.*

By E. W. Claypole, Akron, O.

This little work is an unpretending but useful compilation intended to put within the reach of intelligent readers some of the fundamental facts on which rests the "Evolution Theory." As the writers truly remark in their preface, "few, except special students of the natural or physical sciences, really know what is meant by organic evolution. Ask," they say, "the average graduate of a high school, an academy, or even of one of our minor colleges to state his conception of the theory. One is ashamed to quote the ready but unmeaning reply, which not seldom would be: Oh, I only know that Darwin thought we were de-

* The Development Theory by J. Y. & Fanny D. Bergen. Lee & Shepard, Boston.

cended from monkeys." With this object the writers have wisely abstained altogether from indulging in theorizing or fine writing, and have confined themselves to stating facts in the simplest language, and leaving these facts to speak for themselves.

The first chapter states the subject, setting forth the rival theories of creation by evolution and by special act. In the second chapter some of the most striking known cases of the development of new species are quoted, and the imaginary nature of the line between species and varieties is forcibly brought out. We are tempted to quote one by way of illustration:

"At Steinheim, in Wurtemberg,* Germany, was once a small lake, and its waters grew countless little shell-fish, many of them water-snails like those of the rivers and lakes at the present day. By the appropriation of the dissolved limestone in the waters of the lake, generation after generation of these snails built up their shells, only to let them fall to the bottom on the death of the little inhabitant. By this slow process a layer of shell-mud was formed, which has since hardened into chalk. About forty distinct layers of this chalk may be distinguished, containing the perfectly preserved remains of many shells. And now for the wonderful part of the story. The shells of each layer remain much the same throughout its thickness, but toward the limit of each, or before the beginning of the next, the shells are observed to vary, so as to approach the form which will be found in the next layer. And not only are the shells of the lowest layer so different from those of the highest that if the intermediate forms had not been discovered they would certainly be called different species, but there are many among the intermediate forms themselves which, if they had been found separate from the others, would have been counted distinct species."

A diagram accompanies this extract, showing a gradual but steady change of form from flat, discoid, planorbiform shells at the base of the deposit to others with elevated spire at the summit. No two of the series would probably pass as the same species among conchologists, as every one acquainted with the fine splitting prevalent among American Unios and Melanians will

* Schmidt, Descent and Darwinism, pp. 97, 98.

readily admit. In the third chapter are mentioned the causes which, so far as is known, can and do develope variation. They are summed up in the following sentence:—"Any change in the circumstances, *i.e.*, the sum total of the influences affecting any organism, will be likely to work some alteration in that organism or its descendants, or both." In confirmation of this position the well-known instance of the brine-shrimp (*Artemia—Branchipus*) is brought forward. A more obvious one, that of the Axolotl, we extract, somewhat condensed.

"The Mexican Axolotl is a tadpole-like creature of considerable size which lives in the water, breathes by gills, and is reproduced from eggs. In its native country this creature is not known to change its form.

"Now in 1867 it was observed at the Jardin des Plantes, in Paris, that some of these animals cast their skins after crawling out of the water, and began a new existence in the shape of a common Salamander (*Amblystoma*). This astonishing change from Axolotl to Salamander is accomplished in from fourteen to sixteen days, and, it seems, may always be brought about in healthy specimens by placing them in shallow water and gradually diminishing the supply. The Salamanders so produced lay eggs which hatch into tadpole-like larvæ that soon grow into Salamanders." Several other cases of the same kind are given by the authors for which we must refer the reader to the work itself.

In reference to this part of the subject it is only fair to remark that not a few cases can be quoted in which organisms have refused, and do constantly refuse, to vary in spite of very great changes of environment. Darwin called attention strongly to this fact, and others have since done the same. Yet, allowing full weight to the objection, it forms no insuperable barrier in the path of the evolutionist. We know not what counteracting influences may be at work to prevent the expected variation. Even if with Darwin and others we attribute the refusal to vary to a resistance on the part of the organism, yet that resistance may be an outcome of past conditions, possibly a deep-seated and long enduring habit. Strong and well established facts proving variancy under varying conditions cannot be set aside by negative facts. Similar difficulties are encountered by all great generalization. The Copernican theory of the universe stumbled

at first among many such obstacles, but one by one they have been removed, and we may reasonably anticipate the same result in the case of the theory of Organic Evolution.

"Natural Selection" forms the topic of the fourth chapter. This doctrine, called by Herbert Spencer the "survival of the fittest," determines which among the numerous varieties produced by environment shall live and which shall die. As the Spartan council inspected each new-born infant, and decided whether it should be reared as a citizen-soldier of the state or exposed on Mount Taygetus to die of starvation, so natural selection sits in judgment over every nurseling, and according to circumstances pronounces its doom. If in harmony with its surroundings, it may live; if in discord, it must die. If more suited to its environment than its ancestors, it may even multiply and crowd them out of existence. "Variation," says Prof. Asa Gray, "is the wind, but natural selection is the rudder that guides the organism." The mode in which natural selection acts in thus directing the future form of the organism, is well illustrated by the authors with numerous and obvious examples.

In connection with this important branch of the subject we may remark that human selection is now in many cases far more influential than natural selection, in determining the survival of varieties. But the principles of human selection are often very different from those of nature apart from man. Nature preserves only those most fit to take care of themselves in the struggle for existence. Man often preserves those who would have no chance in such a warfare. The weak in mind or body, whom nature and Sparta would have condemned to speedy death, are kept alive; sentiment forbids their abandonment to their natural fate. The wisdom of this policy is sometimes called in question by sanitarians, but, whether wise or unwise, it is established beyond overthrow. Beyond doubt the prevailing practice tends to entail a terrible burden on our civilization. Prof. A. M. Bell has recently called attention to the danger of creating a race of deaf-mutes, by the constant preservation and perpetuation of such persons. It is however too wide a subject to be here discussed, and leads to other and greater problems with which future sanitarians and legislators must deal. If the sympathies of man will not allow the

laws of nature to take their course cannot the production of such forms be avoided or prevented?

Among domesticated animals human selection is by far the most potent factor. "It was said that in England the introduction of short-horned cattle operated almost like a pestilence in the destruction of the earlier and less-improved breeds. The comparison means that the owner of the old sorts killed them off for meat at such a rate as to thin them out as fast as the cattle-plague could have done." Yet the short horns would be ill-fitted to hold their own in a free-fight for existence among long-horned competitors. Man, however, finds that they come more quickly to maturity, are consequently cheaper to raise, and their meat is of fine quality. Hence he decides that they shall live, and the long-horned races go down before them.

One of the most interesting chapters in the book is that which treats of mimicry, a doctrine which maintains that among the processes of natural selection is one whereby varieties accidentally possessing characters belonging to other species, and deriving benefit therefrom, transmit that character to their offspring, and a species arises that resembles or mimics the other. This is one of the most curious fields in the domain of evolution, and one which will reward, as well as any, patient and careful observation. Very little is at present known on the subject, but that little is strongly suggestive to the thoughtful mind of the intensity of the struggle for existence, and the minuteness of the difference on which success or failure may depend. We must refer the reader to the work for examples of this doctrine and for others illustrating the keen competition among plants and insects for mutual advantages in the fertilization of the former and the feeding of the latter.

The marvellous testimony of embryology to evolution is next considered; and some of the leading well-ascertained facts detailed. These point like index-fingers to a common ancestry for all living beings, they point along converging roads to a spot at some epoch in the past, where all these diverging ways started from a common centre. No one in this country has contributed so much to the embryological argument in favor of evolution as Prof. L. Agassiz, himself one of its most determined opponents. The close and accurate study of the antenatal history of organic

beings has revealed a multitude of facts which have been generalized by Haeckel into the law, that "the history of the development of the individual portrays the history of the development of its tribe." Thus, then among the successive changes of the egg from its first formation to the exclusion or birth of the animal, we may read with our own eyes a concise summary of its development through a long series of ancestors, whose remains are entombed in the rocks or destroyed for ever by geologic catastrophes. Embryology thus enables us to read in miniature and close at hand, an epitome of the greater record which the lapse of time has removed almost beyond our ken, and its accidents have in great part effaced.

Confirmatory of the testimony of embryology is that of geology, which forms the subject of the next chapter. These two records confirm and supplement each other. It is not probable that the former can ever supply all the details of the past history of any species. It is certain that from the record of the latter many chapters are missing, and will never perhaps be recovered. But geology is supplying ample evidence that the deductions of embryology are well founded, and embryology is furnishing unmistakable indications of the line which descent has followed in the production of existing species. Both records are as yet very incomplete, and call for years of patient labor and thought to lessen their imperfection. But every advance in the same direction, every new fact points the same way. "Missing links" come to light connecting species with species in the past, and every one adds vastly to the force of the cumulative argument. With the discovery of every one, the gaps remaining become less important, and before long the induction may become sufficient to warrant the acceptance of a universal inference by every unbiassed mind.

"Wherever the known incompleteness of the geological record, 'prevents our explaining' a difficulty, it becomes the believer in the development theory frankly to acknowledge that the riddle is too intricate to be solved by any means at his command. And yet, until an evolutionary rise of species had been assigned as an explanation of the succession of higher and higher animals and plants through the geologic ages, what adequate reason for this progress could be given? Strike out

from our present conception of the organic world all notion of actual relationship by descent, and what have we left but a mighty list of extinct creatures whose rise, progress and disappearance are far more unaccountable than those of the genii of the Arabian Nights."

We omit the chapter on the geographical distribution of animals and plants—a new-born science which under the labors of Wallace and others, is yielding valuable results in the same direction, and pass on to that on the origin and antiquity of man. This will prove to many readers the most interesting in the volume. Those who believe with the authors in the Evolution of Man from a lower form, will find some facts on which they can base a rational faith. Those who reject such an ancestry for themselves would do well to calmly and dispassionately consider the evidence before giving way to prejudice. Our authors write:—"In order to gain a clear conception of the geological relation of man, let us recapitulate the life-history of the individual from the beginning. We shall find the future human being a mere nucleated cell, a little speck of albuminous jelly, the mammalian egg. So closely do the form, the size, and the structure of this little cell remind us of the amœba-cell that Haeckel's inference is most natural. The ancestors of the higher beings must be regarded as one-celled beings similar to the amœbæ which at the present day occur in our rivers, pools and lakes. The incontrovertible fact that each human being develops from an egg which, in common with those of all animals, is a simple cell clearly proves that the most remote ancestors of man were primordial animals, of this sort, of a form equivalent to a simple cell. When therefore the doctrine of the descent of man is condemned as 'horrible, shocking, and immoral,' the unalterable fact, which can be proved at any moment under the microscope, that the human egg is a simple cell in no way different from those of other mammals must equally be pronounced horrible, shocking, and immoral."

The close resemblance of structure between man and the higher apes so often pointed out is brought forward, and the sole cause of man's superiority is shewn to lie in his brain, there being not a few serious deficiencies in other organs which set him at a disadvantage in comparison with some of the lower animals. Several

of these are mentioned, the vermiform appendage, the coccyx or rudimentary tail, and the eye, in which Helmholz has pointed out six decided optical defects. We may here remark that a valuable and interesting paper by Dr. Clevenger on this topic may be found in the American *Naturalist* for 1884 containing additional facts and establishing some physical disadvantages of the erect position in man.

Dwelling for a short time on the low and degraded moral condition of savage man, the author adds:

"The most inhuman monster of crime that ever was condemned by a court and executed by an officer of the law would, among such tribes as those of the Australian natives, pass for the embodiment of all excellencies, and rise to an uncontested chieftainship. Yet out of such elements, and from the midst of such degradation, scientists must conclude that the human race as it is now has risen."

A few pages on the fossil remains of man conclude the work, showing that archæology has already amassed sufficient facts to prove man's presence on earth for a vastly longer time than was formerly supposed, or, at all events, the existence of a creature, man, ape, or intermediate, capable of forming and using weapons and tools of chipped flint. Bones are as yet very scarce, but implements are abundant, of whose artificial nature no doubt can exist. As the worker was before his work, so the maker of these tools, whatever he was, must have existed before they were made.

Twenty-five years ago, the antiquity of man and his development from lower animals were subjects mentioned only with bated breath as awful possibilities of which heretical scientists were beginning to speak. But the world moves, Kent's cavern and many others have been ransacked, river-gravels have been searched, lake-beds examined, and peat-mosses and kitchen-middens dug over, until now the wealth of evidence is bewildering to all but the antiquarian specialist. The proof of man's antiquity is unassailable, and that for his development is rapidly becoming unanswerable.

In closing this sketch of a subject for which the little book noticed at the outset has furnished a text, we need only say that to the general reader who wishes to obtain some firm foundation of fact regarding the theory of evolution, and who has neither the

time nor the technical knowledge necessary for the perusal of strictly scientific works we heartily recommend it. To college-students and scholars in high schools also, who do not wish to go out into life unacquainted with the grandest generalization of our day, we also advise its perusal. And all who wish to make acquaintance with the fundamental facts of evolution, whether called by the name of Darwin or any other, and who are not too blinded by prejudice to read and reason fairly, we commend this little work, the composition of a period of enforced seclusion from active life on the part of one of its authors.

VII. The Late J. George Jeffreys, M.D., F.R.S.

By Sir J. W. Dawson.

A late British mail brings the intelligence of the death of this eminent naturalist, probably the oldest British zoologist next to Owen, and at the time of his decease generally recognised as the most eminent conchologist in Great Britain. Dr. Jeffreys was born at Swansea in January, 1809. He was a zealous collector of shells from his youth, and was one of the earliest scientific dredgers on the shores of Great Britain. He took a leading part in connection with some of the sea-expeditions of the English and French governments, and at the time of his death was busily engaged in the investigation of the mollusca dredged by the Porcupine. Besides his great work in British conchology, he was the author of a large number of memoirs in the Transactions of the Royal, Linnæan and other Societies. He was a man of broad general views, as well as of attention to details, and was especially interested in the relation of the subject to physical geography and the history of genera and species in geologic time. In connection with this he took much interest in the discoveries recently made in this country, and some of his most recent papers had reference to the relations of European and American mollusca. He was in correspondence with many of the leading workers in modern and pleistocene mollusks in the United States and Canada. When in Canada some years ago he was the guest of Sir William Logan, and spent much time in inspecting the collections of Dr. Carpenter at McGill College, and in examining the dredgings of Mr. Whiteaves in the collections

of the Natural History Society. He had given some attention to the study of entomology, but his life-work related to the natural history and distribution of the mollusca. As to his kindly and genial nature and friendly and public-spirited disposition, all of his many friends on both sides of the Atlantic well agree with the statements in the following extract from the obituary in the London *Times*:—

"Almost from its foundation he was a constant and prominent attendant at the meetings of the British Association; he was president of the biological section in 1877, and one of the vice-presidents at the meeting in Swansea in 1880. With his keen interest in the promotion of biological research generally, he was one of the founders of the Marine Biological Association of Great Britain. For forty-five years he has been a Fellow of the Royal Society, and latterly one of the guiding spirits at the Royal Society Club. At the age of twenty he was elected to the Linnæan Society. Of the Geological Society he was treasurer for many years, and of many foreign societies he was an honorary member. Dr. Jeffreys, while strong in his own opinions, was one of the most genial of men, and a man of many friends. He was not a Darwinian in the full sense of that term; he thought the evidence of his shells was against the doctrine, but his opposition had nothing of bitterness. Dr. Jeffreys occupied several important public positions during his lifetime. He was a J.P. of Glamorganshire and Breconshire, as also J.P. and D.L. of Hertfordshire, for which county he served as High Sheriff in 1877. In recent years he has lived mostly at Ware Priory, Herts, where he delighted to exercise a liberal hospitality. Dr. Jeffreys had a son and five daughters, one of whom is married to Professor H. N. Moseley."

VIII. Report of the Geological Society of London.

March 25, 1885.—Prof. T. G. Bonney, D.Sc., LL D., F.R.S., President, in the Chair. The following communications were read: "On an almost perfect Skeleton of *Rhytina gigas* —*Rhytina stelleri* ('Steller's sea-cow') obtained by Mr. Robert Damon, F.G.S., from the Pleistocene Peat-deposits on Behring Island." By Henry Woodward, LL.D., F.R.S., F.G.S.

The author spoke of the interest which palæontologists must always attach to such animals as are either just exterminated, or are now in course of rapid extirpation by man or other agents. He referred to the now rapid destruction of all the larger mammalia, and expressed his opinion that the African elephant, the giraffe, the bison and many others, will soon be extirpated unless protected from being hunted to death. The same applies to the whale and seal-fisheries. He drew attention to a very remarkable order of aquatic animals, the Sirenia, formerly classed with the Cetacea by some, with the walruses and seals by others, and by De Blainville with the elephants. He particularly drew attention to the largest of the group, the Rhytina, which was seen alive and described by Steller in 1741. It was then confined to two islands (Behring Island and Copper Island). In forty years (1780) it was believed to have been entirely extirpated. It was a toothless herbivore, living along the shore in shallow water, and was easily taken, being without fear of man. Its flesh was good, and it weighed often three or four tons.

The author then described some of the leading points in the anatomy of Rhytina, and indicated some of the characters by which the order is distinguished. He referred to the present wide distribution of the Sirenia:—*Manatus* with three species,* namely, *M. latirostris* occupying the shores of Florida and the West Indies; *M. americanus*, the coasts of Brazil and the great rivers Amazon and Orinoco; *M. senegalensis*, the west coast of Africa and the rivers Senegal, Congo, etc.

Halicore with three species,* namely *H. tabernaculi*, the Red

* Dr. Murie affirms, that, after examination of many specimens, he believes that only two species exist at the present day, one of Manatus, and one of Halicore.

Sea and east coast of Africa; *H. dugong*, Bay of Bengal and East Indies; *H. australis*, North and East Australia.

The fossil forms number thirteen genera and twenty-nine species, all limited to England, Holland, Belgium, France, Germany, Austria, Italy, Malta, and Egypt, and to the United States and Jamaica.

The author gave some details as to the dentition of fossil species, of which Halitherium and Prorastomus are the two most remarkable types.

Lastly, with regard to the geographical area, occupied at the present day by the Sirenia, the author pointed out that two lines drawn 30° N. and 30° S. of the Equator, will embrace all the species now found living. Another line drawn at 60 N. will show between 30° and 60° N. the area once occupied by the twenty-nine fossil species.

He looked upon Rhytina as a last surviving species of the old tertiary group of Sirenians, and its position as marking an "outlier" of the group now swept away.† The greater northern extension of the group seems good evidence of the once warm climate enjoyed by Europe, Asia, and America in the tertiary period.

IX. Proceedings of the Natural History Society.

for 1883-84.

(*Continued from page* 64.)

The *Fourth Meeting* of the session was held on Monday evening, March 31st, Dr. T. Sterry Hunt in the chair. After discussion concerning the Society's Journal, the following were appointed an editing committee: Dr. Hunt, Dr. Harrington, J. T. Donald, D. P. Penhallow and D. A. P. Watt.

Messrs. F. B. Caulfield, C. J. Young, J. J. Robson and E. O. Robert were elected ordinary members of the Society, and Messrs. A. Inglis and Thos. Devine were proposed for membership.

† Only three or four examples of the reconstructed skeletons of Rhytina are known at the present day, viz.:—a nearly perfect skeleton in the St. Petersburg Museum (described by Nordmann and Brandt), a less perfect one at Stockholm (obtained by Nordenskiold) and the one now under consideration, obtained by Mr. Damon.

The President then read a paper on, "The Genesis of Crystalline Rocks," after which the meeting adjourned.

The *Fifth Meeting* was held April 28th, Mr. J. H. Joseph, vice-president, in the chair.

Mr. W. F. Ferrier was appointed to represent the Society at the third annual meeting of the Royal Society of Canada. Messrs. Sumner, Beaudry, Marler and Shearer were appointed a committee to superintend all others relating to the Society's annual field-day.

A suitable minute referring to the death of Mr. F. W. Hicks, formerly recording secretary to the Society, was placed on record.

Messrs. A. Inglis and Thos. Devine were elected ordinary members, and the Bishop of Huron was proposed for honorary membership.

Two papers were then read; one by Mr. F. B. Caulfield, who explained the characteristics and habits of the British game-birds presented to the Society last year by Mr. Jowett of Sheffield, England, and one by Mr. G. L. Marler on "An unread Leaf in Botany."

The *Annual Meeting* was held on May 26th. The president, Dr. Hunt, occupied the chair. After routine business Mr. John S. Shearer presented the Report of Council for the Session 1883–84.

Mr. G. L. Marler read the treasurer's report and financial statement.

Mr. Wm. Muir read the report of the Museum and library committee.

The editor of the Society's Journal reported, but his report was referred back to the editing committee. The other reports were adopted and ordered to be printed in the journal.

Mr. P. S. Ross referred to the small amount received for membership fees during the year, and suggested that some better method of collection be adopted.

The election of officers was then proceeded with and resulted as follows:—

President, Dr. T. Sterry Hunt.

Vice-Presidents, Dr. J. W. Dawson, Dr. B. J. Harrington, Dr. W. H. Hingston; Messrs. J. H. Joseph, L. A. Hugnet Latour,

J. H. R. Molson, Rev. R. Campbell, Edward Murphy and Dr. Osler.

Corresponding Secretary, Dr. J. Baker Edwards.

Recording Secretary, Geo. Sumner.

Treasurer, G. L. Marler.

Cabinet-keeper and Librarian, Wm. Muir.

Council, J. S. Shearer, J. Bemrose, M. H. Brissette, W. T. Costigan, J. S. Brown, P. S. Ross, J. T. Donald, R. W. McLachlan.

Library Committee, Dr. Wanless, H. Graham, E. T. Chambers Dr. McLaren, J. S. Brown.

Editing Committee, Dr. Hunt, Dr. Harrington, J. T. Donald, D. P. Penhallow, Dr. Wanless.

Mr. G. L. Marler gave notice of a motion to the effect that young men under eighteen years of age be allowed to become associate members upon payment of a yearly fee of one dollar.

A vote of thanks being tendered to the retiring officers the meeting adjourned.

Report of Council, May 26th, 1884.

Your Council have to report that during the season now closing the society has elected twelve members.

The number of persons who have visited the Museum during the year is about 3,300 The lectures of the Sommerville course were delivered as follows: February 14th, Prof. Penhallow, On Tea; February 21st, Prof. Bovey, on Conservation of Force; February 28th, Dr. Major, on The Voice; March 6th, A. T. Taylor, Esq., on Health in our Homes; March 13th, Dr. T. Sterry Hunt, on The Food of Plants; March 20th, Dr. W. George Beers, on A Child's Teeth.

These lectures were well attended, and well received, and the thanks of the Society are due to the gentlemen who delivered them.

It is now a settled fact that the British Association for the Advancement of Science are to meet in Montreal on the 27th of August next, and this Society will do all in its power (as they did when the American Association visited Montreal in August, 1882) to make the meeting of the British Association successful. The use of our building has been placed at the disposal of the

various committees. It is our pleasing duty to record the election from our number of Dr. J. W. Dawson, Dr. T. Sterry Hunt, and Dr. Hingston as vice-presidents of the British Association.

The Society held their *Annual Field-day* on the 8th of June, 1883, at Rougemont, through the kind invitation of Mr. George Whitfield. The day was fine, and a large number availed themselves of the invitation. The start was made from the G.T.R. station at 9 a.m., by the South Eastern Railway, arriving at Rougemont station about 10.45. Mr. Whitfield's farm, which was soon reached, is beautifully situated at the foot of the Mountain, and from his house a fine view of the country for miles around was visible, giving the visitors an excellent opportunity of seeing the highly cultivated land that lay as it were at their feet.

A light collation was provided by our kind hostess, Mrs. Whitfield, after which the party divided into groups, some bent on seeing the country from the top of the mountain, while others started to examine the geology and the botany of the neighborhood.

At noon the several parties returned, as prearranged, to inspect the farm and the numerous herds of high-bred cattle. The whole company then sat down to a bountiful and well-served dinner, at the close of which our esteemed President, Dr. Hunt moved a hearty vote of thanks to Mr. and Mrs. Whitfield, heartily responded to by all present.

During the afternoon Dr. Hunt gave an able and interesting lecture on the geology of that part of the country. The collections made during the day having been brought in and examined, prizes were awarded as follows:—

Collection of named plants (Ladies' prize) Miss E. Martin. Collection of named plants (Mens' prize) Mr. E. Blackader. For collection of unnamed plants Miss Carsley and Miss Cooper, equal. Entomological prize, Mr. R. C. Holden; Geology and Mineralogy, Mr. G. R. Martin. The day being well nigh-spent the party prepared for returning, first giving thanks to Mr. and Mrs. Whitfield for the pleasant day they had spent, and soon after reached the station and the train, arriving home shortly after 9 p.m.

An effort should be made by the Society to increase its membership and secure a greater interest in its proceedings, which would enable us at the same time, in some measure, to keep up the

income, in view of the withdrawal of the Government Grant; and a committee on membership should be appointed by the incoming officers for that purpose.

Six regular meetings of the Society have been held during the year, and eight meetings of the council.

Report of the Cabinet-Keeper and Librarian for the year ending May 18th, 1883

Your Treasurer will report to you the state of our finances and Mr. Muir will report on the Museum and Library.

The whole respectfully submitted.

Work on the building: The old counter-desk in the lecture hall has been taken down and replaced by a light and handsome reading-stand. Shelves have been fitted up in the library for the reception of periodicals, pamphlets, etc.

Work in the museum: Mr. Caulfield has cleaned and arranged the exotic insects; this finishes the work on the entomological collections, all of which are now in good order.

The following is a list of the donations to the Museum during the year, with the names of the donors :—

Osprey (*Pandion haliaetus*) Acadian Owl (*Nyctale acadica*) Blue Bird (*Sialia sialis*)	Mr. W. L. Marler, St. Johns, P.Q.
Wood Duck (*Aix sponsa*) Velvet Duck (*Melanetta velvetina*)	Mr. L. J. McDonald, St. Johns, P.Q.
Herring Gull (*Larus argentatus*) Bonaparte Gull (*Larus philadelphiæ*)	Mr. G. L. Marler.

By purchase,

European Hen Harrier. (*Circus cyaneus.*)

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THE CANADIAN

RECORD OF SCIENCE

INCLUDING THE PROCEEDINGS OF
THE NATURAL HISTORY SOCIETY OF MONTREAL.

AND REPLACING

THE CANADIAN NATURALIST.

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1885.

EDITING COMMITTEE.

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T. STERRY HUNT.
A. H. MASON.
W. T. COSTIGAN.
R. W. BOODLE.

July, 1883.

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VOLUME I. ... ... NUMBER 3

I. THE CLASSIFICATION OF NATURAL SILICATES. *

(Abstract.)

BY T. STERRY HUNT.

The author in this paper reviewed the history of mineralogy, and noticed the method of classification of mineral species based solely on physical characters, which makes mineralogy a division of natural history. He then proceeded to consider the method of those who have arranged mineral species in accordance with the results of chemical analysis, while disregarding or giving a subordinate place to physical characters. A true philosophy, it was contended, should keep in view both of these methods: the chemical cannot be separated from the physical study of species, and a thorough knowledge of the chemical constitution of these will show that their physical characters are intimately related thereto, and will lead to a natural system in mineralogy.

The author in attempting the elaboration of such a system, the importance of which is evident, begins by showing in the present paper its application to natural silicates. These he regards as polysilicates of high equivalent weight, in accordance with the view

* The paper of which this is an abstract was presented to the National Academy of Sciences at Washington, April 23, and to the Royal Society of Canada at Ottawa, May 27, 1885. It will be published at length in the Transactions of the last named Society for 1885.

put forward by him in papers published in 1853 and 1854, when wollastonite was referred to a polysilicic acid with $11SiO_2$, and pyroxene to one with $14SiO_2$, or perhaps some simple multiple of these numbers, with an equivalent volume, probably not less than 460. In such compounds the degree of complexity of the molecule is shown by the relation to space of the chemical equivalent, or, in other words, by its volume. To arrive at a term of comparison for this relation in species of various and unknown degrees of complexity, the author deduces for each silicate the mean equivalent weight of its atomic unit, corresponding to an atom of NaCl; for which purpose H_2O and CaO are divided by two; SiO_2 by four, and Al_2O_3 by six. The mean unit-weight thus deduced from any arbitrary chemical formula, when divided by the specific gravity of the species gives the volume of the unit, which serves to show for different species the relative condensation of the molecule. The hardness and the chemical relations of species will be found to vary with the unit-volume, as is shown in the tables given below.

The various relations just described may be illustrated by an example. The simplest atomic formula representing the chemical elements of meionite and zoisite (which have the same centesimal composition) is $(ca.al_2.si_3)\ o_6$; the small letters representing atoms and $o = 8$. This gives an equivalent weight of 107, which, divided by six, shows the mean weight (P) of the unit or oxyd-atom in these species to be 17.83. Dividing this latter number by 2.7, the specific gravity of meionite (water = 1.0), we have for the volume of the oxyd-atom in this species, $V = 6.60$. Dividing by 3.4, the specific gravity of zoisite, we find that $V = 5.24$. The true formulas and equivalent weights of these two complex silicates must be deduced from a comparison of their specific gravities with those of other species whose equivalent weights are otherwise determined. Meanwhile it will be seen that the species zoisite, having the lower value of V, or the more condensed molecule, differs from the less dense meionite in its greater hardness and its superior resistance to acids. Mineralogy affords many examples of the principles here illustrated.

From the complex constitution thus assigned to silicates it follows that the comparatively simple ratios generally deduced for the silica and the various bases are, in many cases, but approx-

imations to the more complex ratios really existing. These, from the frequent impurities of natural silicates, can seldom be fixed with exactness, although with sufficient precision to give very nearly the values of P and V, which latter serves to determine the place of the species in the natural system of classification. Water being an element universally distributed in nature, its presence or absence in a silicate becomes of subordinate importance in determining alike the genesis and the natural affinities of species. Hence the water-ratios are omitted in the tables of classification, wherein the various natural silicates are from the chemical side, considered with regard to the atomic ratios of the fixed bases to each other and to silica.

There are genetic reasons (which were explained at length) for separating silicates of sesquioxyd-bases, like alumina, from protoxyd-silicates. The former of these constitute the Persilicates, and the latter the Protosilicates, those containing both protoxyds and sesquioxyds being designated Protopersilicates. Ferric oxyd and zirconia are classed with alumina, while titanic and boric oxyds in silicates are counted with the silica in determining the atomic ratios.

In the table of the Protosilicates, and in that of the Persilicates, both hydrous and anhydrous, the generally accepted atomic ratios of the fixed bases to the silica are noted, but in the table of the Protopersilicates regard is had to the more important ratios of the sesquioxyd and fixed protoxyd bases to each other, inasmuch as the ratio of the silica to both of these is found to vary greatly in closely related species, as may be seen in zeolites, feldspars, scapolites and micas. In these tables the three groups of silicates are arranged with primary reference to physical characters. Thus for Protosilicates we have in parallel vertical columns Pectolitoid, Spathoid, Adamantoid, Phylloid and Ophitoid, for each of which the range of values for V is given, while in an adjacent column are inscribed the approximate atomic ratios of fixed protoxyds to silica. Among pectolitoids are included with pectolite, apophyllite and datolite, hydrorhodonite, dioptase, pyrosmalite, calamine, cerite and thorite. The spathoids embrace tephroite, willemite, gadolinite, helvite, leucophanite, tscheffkinite and wollastonite; the adamantoids, chondrodite, chrysolite, phenacite, bertrandite, hornblende, pyroxene, titanite,

Order SILICATE.

Sub-Order A.—PROTOSILICATE.

r : si.	Pectolitoid. V = 7·0—5·3	Spathoid. V = 6·7—6·0	Adamantoid. V = 6·0—4·6	Ophitoid. V = 7·3—5·5
1 : ¼	- - - - - - - - - - -	- - - - - - - - - - - -	Chondrodite.	
1 : 1	Calamine. Thorite. Cerite. -	Willemite. Batrachite. Tephroite. Gadolinite. Helvite.	Monticellite. Chrysolite. Phenacite. Bertrandite.	Villarsite. Matricite.
1 : 1½	- - - - - - - - - - -	Leucophanite. - - - - - - -	- - - - - - - - - - -	Serpentine. Retinalite.
1 : 1⅔	Gyrolite. Pyrosmalite.	- - - - - - - - - - - -	- - - - - - - - - - -	Deweylite. Genthite.
1 : 2	Xonaltite. Plombierite. Hydrorhodonite. Dioptase.	Wollastonite. Tscheffkinite. -	Hornblende. Pyroxenides.	Picrosmine. Aphrodite. Cerolite. Chrysocolla.
1 : 2⅓	Pectolite. - - - - - - -	- - - - - - - - - - - -	Hornblende. - - - - -	Spadaite.
1 : 2½	- - - - - - - - - - -	- - - - - - - - - - - -	- - - - - - - - - - -	Talc. Rensselaerite.
1 : 3	- - - - - - - - - - -	- - - - - - - - - - - -	- - - - - - - - - - -	Talc. Sepiolite. Glauconite.
1 : 3½	Datolite.			
1 : 4	Apophyllite. Okenite. - - -	- - - - - - - - - - - -	Guarinite. Titanite.	
1 : 7	- - - - - - - - - - -	- - - - - - - - - - - -	Danburite.	

and danburite; while the phylloids embrace thermophyllite and talc, and the ophitoids, the various hydrous silicates, of which villarsite, serpentine and deweylite are representatives.

Order SILICATE.

SUB-ORDER B.—PROTOPERSILICATE.

R : r : Si.	ZEOLITOID. V = 7·2—6·3	SPATHOID. V = 7·2—6·0	ADAMANTOID. V = 5·8—4·7	PHYLLOID. V = 6·2—5·1	
1 : ½ : m	- - - - - -	Melilite. Eudialyte. -	Keilhauite. - - - - - - - - - -	MICAS. Phlogopite. -	CHLORITES. A large group of hydrous magnesian species.
1 : ¾ : m	- - - - -	- - - - - - - - -	Idocrase. Ilvaite. Schorlomite (1 : ¾).	Phlogopite.-	
1 : 1 : m	Xanthorthite. -	{Gehlenite. Sarcolite. / Milarite. Wöhlerite.}	Garnet. Allanite. Beryl. - - - - -	Biotite. - -	
1 : 1½ : m	Prehnite. - -	Beryllite. - - - - -	Euclase. Ardennite. - - - - -	Seybertite.	PINITOID.
1 : 2 : m	{Hamelite. / Caespitelite.}	SCAPOLITES. - - - -	Axinite. Epidote. Zoisite. Jadeite. -	Biotite. - -	Jollyte. Palagonite,
1 : 3 : m	ZEOLITES. - - -	FELDSPATHIDES. - -	- - - - - - - Coronite.	Chloritoid. -	Fahlunite-Bravaisite
1 : 4 : m	- - - - - -	Petalite. - - - - -	Spodumene. [Stanrolite. Sapphirine. Schorlite.	Lepidolite. -	Hygrophilite (1 : 5).
1 : 6 : m	Forestite. - -	- - - - - - - - -	- - - - - - - - - TOURMALINES.	{Margarite. / Muscovite.}	
1 : 8 : m	- - - - - -	- - - - - - - - -	- - - - - - - - - Aphrisite.	Euphyllite. -	Pinite.
1 : 9 : m	- - - - - -	- - - - - - - - -	- - - - - - - - - Indicolite.	{Damourite / Muscovite.}	Cossaite.
1 : 12 : m	- - - - - -	- - - - - - - - -	- - - - - - - - - Rubellite.	Muscovite. - (With other species).	Gümbellite.

The Protopersilicates are grouped under the heads of Zeolitoid, Spathoid, Adamantoid, Phylloid and Pinitoid; while in a column to the left are given the atomic ratios of fixed protoxyds and sesquioxyds, the silica being variable. The zeolitoids include, besides the zeolites proper, forestite, prehnite, catapleiite, xanthorthite, etc. Under the spathoids of this class are placed petalite, all feldspars and feldspathides, including sodalite, iolite and leucite; the scapolites, including meionite; barylite, milarite, gehlenite, sarcolite, melilite, wöhlerite and eudialyte. The adamantoids comprise pargasite, keilhauite, schorlomite, ilvaite, idocrase, garnet, allanite, beryl, euclase, ardennite, axinite, epidote, zoisite, jadeite, spodumene, staurolite, sapphirine, and the various tourmalines. In the phylloids are included the micas proper, from phlogopite and biotite, through seybertite and chloritoid, lepidolite, margarite and euphyllite to the muscovites and damourite. With the magnesian micas are placed, under the head of phylloids, the whole family of chloritic species, while parallel with the non-magnesian or muscovitic micas, are ranged the pinitoids, including besides pinite or gieseckite, jollyte, fahlunite, bravaisite, cossaite and gümbellite.

Order SILICATE.

Sub-Order C.—PERSILICATE.

r : Si.	Kaolinoid. V = 6·8 — 5·3	Adamantoid. V = 5·3 — 4·4
1 : ¼	Schrötterite.	
1 : ⅓	Collyrite. - - - - - -	Dumortierite.
1 : ⅖	Allophane. - - - - -	Topaz. Andalusite. Fibrolite. Cyanite.
1 : 1	Pholerite. Samoite. - -	Bucholzite. Zircon. Malacone.
1 : 1½	Kaolinite. Halloysite.	
1 : 1⅔	- - - - - - - - - -	Auerbachite.
1 : 2	Pyrophyllite. Steargillite. Chloropal.	
1 : 2½	Pyrophyllite.	
1 : 3	Cimolite. - - - - -	Anthosiderite.
1 : 4	Smectite.	

The Persilicates are arranged in like manner in five groups, the received ratios of silica and the fixed bases being given, as before, in a column to the left. The adamantoid persilicates include dumortierite, andalusite, fibrolite, topaz, cyanite, bucholzite, the zircons and anthosiderite. The phylloids include pholerite, kaolinite and pyrophyllite; and the argilloids, the various amorphous hydrous silicates of alumina from the highly basic schrötterite, through halloysite, to the more silicious cimolite and smectite.

The relations of fluorine in silicates like topaz and chondrodite, of chlorine in pyrosmalite, sodalite and scapolites, and of sulphur in helvite, lapis-lazuli and danalite are considered at length by the author. Tables showing the values of P and V, together with the simplest atomic formulas deduced from chemical analysis are given for most well-known silicates. The discussion of the equivalent weights of these species, and of their definite place in a chemical classification of polysilicates is noticed, but is left for future consideration.

If we regard the silicates as constituting a natural order, the three groups already noticed may be called sub-orders; A. Protosilicates; B. Protopersilicates; C. Persilicates. The divisions of these will constitute tribes, and the tribal characters being repeated in the sub-orders, we distinguish the spathoids, adamantoids and phylloids, by prefixing the distinctive syllables of the sub-orders; as protospathoid, peradamantoid and protoperphylloid. The sub-divisions of these tribes into families, genera and species cannot here be discussed. The genus feldspar, including anorthite, albite and perhaps iolite, with other genera, some of which are represented respectively by orthoclase, by leucite, and by sodalite, will constitute the family of the feldspathides. The families of the micas and the pyroxenides in like manner will each include several genera, having different values for V.

The application of the principles above defined to carbonates, and the reference of the various carbon-spars to different polycarbonates, were long ago shown by the author in his papers already noticed. The extension of like views to all liquid and solid inorganic species, both natural and artificial, is but a matter of detail and labor, and when fully carried out will be the basis of a new chemistry.

II. Recent Discoveries in the St. John Group.†

By G. F. Matthew.

For some years the St. John group has been known as a formation containing the fullest representation of the oldest Cambrian fauna yet discovered in America.

In Europe this very old fauna is well known, but in America the Cambrian rocks which are best known and have been most carefully studied, do not contain it. These Cambrian rocks of America are known as the Potsdam sandstone; they cover extensive areas along the valley of the St. Lawrence and in the Middle and Western States, and are thus the oldest Cambrian group recognized by its fauna in the central region of North America, but they do not contain any of the species of the St. John group.

On the shores of Lake Champlain and along Hudson River another group of Cambrian rocks is found, older than the Potsdam sandstone, but even this, so far as we know, contains none of the St. John species. In short, nowhere west of the Appalachian Mountains have Cambrian strata been met with containing remains of animals of the ancient type of those of the Acadian provinces.

The crustacean genus *Paradoxides* is one of the most characteristic forms of this early fauna, and it has thus far been found in America only to the east of the Appalachian chain. One species is known to occur in Massachusetts, and three in Newfoundland, but the genus is represented by a greater variety of forms at St. John, N. B., than elsewhere on this continent. This genus is considered to be characteristic of the Lower Cambrian rocks. The late Professor C. F. Hartt, by a study of the fossils of the St. John group, was able to declare that they were of the same type as those of the Primordial zone in Bohemia, which Joachim Barrande had shown to contain the oldest of all known organic remains.* But, since Prof. Hartt made this determination, the fauna of the Primordial zone has been further elaborated, and Paradoxides is now found to mark the lower part of the Primordial or Cambrian system. This fact was ascertained for central

† From the Bulletin of the Natural History Society of St John, New Brunswick, read December 2, 1884.

* That is, the oldest known at that time.

Europe by the illustrious Barrande, and for Great Britain by Mr. J. W. Salter and Dr. Henry Hicks. These students discovered that while Paradoxides characterized the Lower Cambrian rocks, the Upper Cambrian could be recognized by the presence in it, among other fossils, of the crustacean genus *Olenus*. Dr. Hicks went further, and was able to divide the Lower Cambrian formation of Wales into three groups, by means of the different assemblages of animals which it contains. He thus established the succession of the groups known as Cærfai, Solva, and Menevian.

Prof. Hartt fixed the age of the St. John group as nearly as was possible in his time, as Primordial, or, as we now call it, Cambrian; but these latter discoveries in Europe have enabled the writer to point out more exactly the Cambrian group in Wales holding a fauna to which the beds containing the St. John fauna described by Prof. Hartt correspond.* This has been shown in a memoir in the Transactions of the Royal Society of Canada (1884) and elsewhere, and we now know that Hartt's species more nearly represent those of the Solva group than those of the Menevian. In other words, it is the fauna of the older part of the Lower Cambrian.

When we look for a source from which our Lower Cambrian fauna may have been derived we are met with the difficulty that no other large assemblage of animals of greater antiquity is known. The oldest creature known, *Eozoon canadense*, so far preceded in time the advent of the Cambrian forms of life that its influence on them is almost beside the question. It is true that a species resembling *Eozoon canadense* has been found in the pre-Cambrian rocks of Bavaria, but the genus *Eozoon* is not known to have left any successors or nearly related forms in the Cambrian limestones, and may therefore be considered as practically extinct at the opening of the Cambrian period.

Coming to more recent times than that represented by Eozoon, there is a Geological stage in Newfoundland indicated by the Intermediate series of Mr. Alex. Murray, in which a single organism has been found. This Intermediate series is regarded by Mr. Murray and others as equivalent to the Huronian system of Canada, and therefore intermediate between the Laurentian

*The two groups, one in Wales and the other in Acadia, are not necessarily on that account exactly cotemporaneous.

(the system containing Eozoon) and the Cambrian. The organic form which occurs in this Intermediate system was described by the late Mr. E. Billings of the Canadian Geological Survey, who appears to have thought it a representative of the Gasteropods (Sea-snails, etc.) and gave it the name of *Aspidella terranovica*. It is a curious patelliform object, which Mr. Billings was unable to refer to any known genus or family, so that its bearing on the question of the origin of the Lower Cambrian or Acadian fauna of the St. John group is somewhat problematical.

In the Acadian fauna of the St. John group, notwithstanding its antiquity, we do not have the ultimate source of organic life, but, on the contrary, an assemblage of animals already greatly differentiated and adapted to the conditions under which they existed. At the time when the Acadian fauna flourished, there may also have been other areas on the globe occupied by living beings, for when we consider the place and mode of occurrence of the species of the St. John basin, belonging to Division or Series 1, both described and undescribed, it is clear that there were three successive irruptions of living forms into this area, all of Lower Cambrian types, and all strictly within the limit upward of the Paradoxidean zone. Each of the three sets of organisms in these beds contains a large proportion of distinct species, with a smaller number of identical species. The latter serve as connecting links to bind these several sub-faunas together as one connected whole.

Before describing the three assemblages of organic forms that are found in the lower part of the St. John group it may be well to give a brief statement of the nature and order of the beds in which they occur. The St. John group has been divided in six principal masses of strata, designated as Divisions (=Series) 0, 1, 2, 3, 4 and 5. Of Division 0, it may be said that no organic remains have been found in it; but in Division 1 is found the fauna described by Professor Hartt and others. This fauna is not found at the base of Division 1, but in one of its middle members. Division 1 at St. John has been described as consisting of four bands of strata, differing in the nature of the sediments, and designated respectively, in ascending order, as *a*, *b*, *c*, and *d*. The band *a* is barren, and *c* contains the species already described; but both *b* and *d* are now found to have each their own peculiar assemblage of species.

The oldest fauna is found in the band *b*. It is littoral, and its deep-sea equivalent is not known, but its crustaceans differ from those of the next band. The connecting link between the fauna of this band and that of the band *c* above it, is found chiefly in the brachiopods and pteropods. In the fauna of *b* are two new types of bivalve crustaceans. The solitary trilobite known, Agraulos (?), is notable for the great development of the axial lobe of the cephalic shield and thorax, and of the close approximation of the eyes to the glabella. In this feature it resembles *Conocoryphe lyellii* of the Welsh Cambrian strata. Two species of the pteropods display the remarkable feature, in this class, of a camerated shell, and were apparently adapted to resist the accidents of life on a sandy sea-shore. As for the brachiopods, we find among them only the most primitive types—Linnarssonia, Lingulella, Acrothele and Acrotreta.

On passing to the beds of band *c* a host of new forms present themselves, among which are two types of sponges, Protospongia (?) and an undescribed genus. The cystidian, Eocystites, also appears at this horizon. To the genera of brachiopods referred to as found in band *b* are now added three species of the genus *Orthis*, and another Lingulella takes the place of that found in band *b*. Among the gasteropods are several genera: *Stenotheca*, *Scenella*, *Harttia*, etc. The pteropods are well represented in hyalithoid species of three different types. The bivalve crustaceans have a fair representation; those of the underlying band are not found but new species appear, including those of the genera *Primitia*, *Leperditia*, etc. The trilobites are represented by the most ancient, genera:—*Agnostus* has four species, *Microdiscus* two, *Ptychoparia* five or more, *Conocoryphe* three, an ancient type of *Ctenocephalus* one, and *Paradoxides* four; all four of this last genus have continuous eyelobes.

Passing to the beds of the new band, viz., *d*, a change in the fauna is at once apparent, though a connection with the preceding fauna is maintained by the presence of the undescribed sponge, all of the pteropods, and two familiar forms of brachiopods—Linnarssonia and Acrothele; there are also varieties of the Agnosti, the Ptychopariæ, and of Protospongia (?) of band *c*. On the other hand, quite a number of new species appear at this horizon, among which may be named a Dendrograpsus (?), another Lin-

gulella, and two new species of Stenotheca. Two worm-casts and new species of bivalve crustaceans also come in at this horizon. Among the trilobites also there are new species; the Agnosti have four; Microdiscus exhibits a new form closely allied to *M. punctatus*, Salter. Among the Ptychoparise some species now appear for the first time, and Solenopleura has a representative. A Paradoxides with shortened eyelobes has left abundant fragments in these measures; it is a species which, by its pleural spines, pygidium and hypostome, is allied to *P. tesseni* of Europe.

This new fauna consists largely of forms similar to those of the Menevian group, and is chiefly remarkable for the great abundance of Pteropods, Microdisci and Agnosti, and for the presence of a Paradoxides with shortened eyelobes. So far as they are at present known, each of the successive sub-faunas has an individuality of its own; that in band *b* contains forms the most remarkable for novelty; band *c* is notable for the variety of species it contains, and band *d* for the abundance of individuals of many of the species. The beds of the band *b* may be said to have been deposited on a sandy shore, those of *c* on a muddy shore, and those of *d* in deeper and more tranquil waters. Volcanic action in the vicinity of the St. John basin seems to have been dormant during the time when the beds of band *a* were laid down, but awoke into activity during the period when the strata of *b* were deposited, and gradually died away while the olive-grey mud beds of *c* were formed. The time when these successive faunas were making their way into the St. John basin was a period of decreasing volcanic action and of gradual subsidence in that area.

In concluding this article, I quote a letter of Prof. Alpheus Hyatt of Boston, well known for his researches among the Cephalopods and Sponges, which relates to one of the new forms noticed in the preceding paper. Prof. Hyatt had very kindly offered to advise me in reference to difficult points connected with the fossils of the St. John group, and I therefore availed myself of this opportunity to place before him the various specimens of pteropodous shells bearing upon the possible early connection of the pteropods with the cephalopods. Unfortunately, the letter giving the details of his examination of these fossils has been lost in transmission, but the general results of the investigation are given in the summary quoted below from a later letter. By way

of preface to Prof. Hyatt's letter I may say that more than one of the early pteropods of the St. John group are remarkable for the presence of several distinct septa at the base of the tube. There are two such species in the band *b*; another, but a longer and narrower kind, is found in the band *c*, and this or a similar camerated shell occurs in the band *d*. Of these species (referring, however, chiefly to the latest) Prof. Hyatt says (February 3, 1885):

"I kept no notes of the details I had observed; my results, however, were quite definite in respect to the main points. These were: (1) The fossil is a Hyolithes allied to *H. undulatus*, Barr. (Syst. Silur. pl. 11, f. 29.) (2) The aspect of a siphon is due to the compression of the sharper against the flatter side, and the form of the sutures, which favors this impression. Barrande figures, as I found after arriving at this decision, a similar case, (pl. 15, figs. 35, 35*a*) of a closely allied species, *H. elegans*. (3) The sutures are similar to those of *H. elegans* in curvature, but wider apart. These fossils with their distinct septa are startlingly similar to certain forms of Nautiloidea, but there is no siphon. They, however confirm Von Jhernig's and my opinion that the Orthoceratites and Pteropods have had a common, but as yet undiscovered, ancestor in ancient times."

III. The Mesozoic Floras of the Rocky Mountain Region of Canada*

By Sir William Dawson.

In a previous memoir, published in the Transactions of the Royal Society of Canada, Vol. I, the author had noticed a lower Cretaceous flora consisting wholly of pines and cycads occurring in the Queen Charlotte Islands, and had described a dicotyledonous flora of middle Cretaceous age from the country adjacent to the Peace River, and also the rich upper Cretaceous flora of the coal formation of Vancouver Island—comparing these with the flora of the Laramie series of the Northwest Territory, which he believed to constitute a transition group connecting the upper Cretaceous with the Eocene tertiary.

*Abstract of a paper read before the Royal Society of Canada, May, 1885.

The present paper referred more particular by to a remarkable Jurasso-cretaceous flora, recently discovered by Dr. G. M. Dawson in the Rocky Mountains, and to intermediate groups of plants, between this and the middle Cretaceous, serving to extend greatly our knowledge of the lower Cretaceous flora, and to render more complete the series of plants between this and the Laramie.

The oldest of these floras is found in beds which it is proposed to call the Kootanie group, from a tribe of Indians of that name who hunted over that part of the Rocky Mountains between the 49th and 52nd parallels. Plants of this age have been found on the branches of the Old Man River, on the Martin Creek, at Coal Creek, and at one locality far to the northwest on the Suakwa River. The containing rocks are sandstones, shales and conglomerates, with seams of coal, in some places anthracitic. They may be traced for 140 miles in the north and south direction, and form troughs included in the Palæozoic formation of the mountains. The plants found are conifers, cycads and ferns, the cycads being especially abundant and belonging to the genera *Dioonites*, *Zamites*, *Podozamites* and *Anomozamites*. Some of these cycadaceous plants as well as of the conifers, are identical with species described by Heer from the Jurassic of Siberia, while others occur in the lower Cretaceous of Greenland. The almost world-wide *Podozamites lanceolatus* is very characteristic, and there are leaves of *Salisburya sibirica*, a Siberian mesozoic species, and branches of *Sequoia smittiana*, a species characteristic of the lower Cretaceous of Greenland. No dicotyledonous leaves have been found in these beds, whose plants connect in a remarkable way the extinct floras of Asia and America and those of the Jurassic and Cretaceous periods.

Above these are beds which, with some of the previous species, contain a few dicotyledonous leaves, which may be provisionally referred to the genera, *Sterculia* and *Laurus*; and still higher the formation abounds in remains of dicotyledonous plants of which additional collections have been made by Mr. T. C. Weston. The beds containing these, though probably divisible into two, groups, may be named the Mill Creek series, and are approximately on the horizon of the Dakota group of the United States geologists, as illustrated by Lesquereux and others. The species are described in the paper, and differ for the most part from those

of the Peace River series, which is probably of the age of the Niobrara group, and, of course, still more from the overlying Laramie group. With regard to the latter, the author adduced some new facts confirmatory of his previously expressed view as to the position of the Laramie at the top of the Cretaceous and base of the Eocene, and also tending to show that some of the plants still held by some palæo-botanists to be of Miocene age are really, in Canada at least, fossils of the Laramie group, and consequently considerably older than is currently supposed. These facts also confirm the views previously expressed of the author as to the Eocene or Laramie age of the fossil plants of Mackenzie River and of Greenland, hitherto usually regarded as Miocene. The collections of plants studied by the author had for the most part been placed at his disposal by the Director of the Geological Survey.

IV. Some Points in the Composition of Soils; with Results Illustrating the Sources of Fertility of Manitoba Prairie Soils.

By Sir J. B. Lawes, Bart., and J. H. Gilbert.

This paper is a continuation of one given by the authors at the meeting of the American Association, held at Montreal in the autumn of 1882, entitled "Determinations of nitrogen in the soils of some of the experimental fields at Rothamsted and the bearing of the results on the question of the sources of the nitrogen of our crops."

The first part of the present paper consists of a résumé of the previous one. It was there shown that when crops are grown year after year on the same land without nitrogenous manure, the produce and the yield of nitrogen decline in a very marked degree. This is the case even when a full mineral manure has been applied; and it is the case not only with cereals and with root crops, but also with Leguminosæ. Further, with this great decline in the annual yield of nitrogen of these very various descriptions of plant, when grown without artificial nitrogenous supply, there is also a marked decline in the stock of nitrogen in the soil. Thus a soil-source of, at any rate, some of the nitrogen of the crops was indicated. Other evidence was also adduced clearly pointing to the same conclusion.

Next, that determinations of the amounts of nitrogen as nitrate in soils of known history as to manuring and cropping, and to a considerable depth, show that the amount of nitrogen in the soil in that form is much less after the growth of a crop than under corresponding conditions without a crop. It was hence concluded that nitrogen had been taken up by the plant as nitrate. In the case of gramineous crops and some others, the evidence points to the conclusion that most, if not the whole, of the nitrogen is taken up from the soil. It is also clear that some, at any rate, of the nitrogen of Leguminosæ has the same source and the results are in favour of the supposition that in some of the cases the whole of it might be so accounted for. Still it is admitted that, in other cases, this seems doubtful.

The conditions and the results of a large number of new experiments are next described. It is found that there is very much more nitrogen as nitrate, in the soils and subsoils down to the depth of 108 inches, where leguminous than where gramineous plants have grown. The results point to the conclusion that under the influence of leguminous growth and crop residue, especially in the case of strong and deep-rooted plants, the conditions are more favourable for the development and distribution of the nitrifying organism; and if this view be confirmed, an important step would be gained towards the more complete explanation of the sources of the nitrogen of the Leguminosæ, which assimilate a very large quantity of nitrogen, including, as above supposed, the nitrification of the nitrogen of the subsoil, which may thus become the source of the nitrogen of such crops. An alternative obviously is that the plants might still take up nitrogen from the subsoil, but as organic nitrogen and not as nitrate. There is however no direct experimental evidence in favour of such a view, whilst some physiological considerations, which are discussed, seem to be against it. Again, results show that the soil and subsoil contain less nitrogen as nitrate after the growth of good crops of *Vicia sativa* than where the more shallow-rooted *Trifolium repens* fails to grow. This is further evidence that the Leguminosæ take up nitrogen as nitrate; and in the experiments in question the deficiency of nitric nitrogen in the soil and subsoil of the *Vicia sativa* plots, compared with the amount of those of the *Trifolium repens* plot to the depth examined, is sufficient to

account for a large proportion of the nitrogen estimated to be contained in the Vicia crops.

Other experiments were quoted, which bear less directly on the point, the results of which are, however, accordant; and they at the same time afford illustrations of the loss of nitrogen that the land may sustain by fallow in a wet season, and therefore of the benefits arising from the ground being covered with a crop which takes up the nitrate as it is produced. To conclude on this part of the subject, it may be considered as established that much, at any rate, of the nitrogen of the crops is derived from the stores within the soil, and that much, and in some cases the whole, of the nitrogen so derived is taken up as nitrates.

This leads the authors to the consideration of the second part of their subject, namely, the sources of the fertility of some Manitoba prairie soils.

Soils from Portage la Prairie, from the Saskatchewan district, and from near Fort Ellice, were first examined. They proved to be about twice as rich in nitrogen as the average of arable soils n Great Britain, and perhaps about as rich as the average of the surface soil of permanent pasture land.

Four other Manitoba soils were examined in greater detail, one was from Niverville, forty-four miles west of Winnipeg, the second from Brandon, the third from Selkirk, and the fourth from Winnipeg itself. These soils show a very high percentage of nitrogen; that from Niverville nearly twice as high a percentage as in the first six or nine inches of ordinary arable land, and about as high as in the surface soil of pasture land in Great Britain. The soil from Brandon is not so rich as that from Niverville, still the first twelve inches of depth are as rich as the first six or nine inches of good arable lands. The soil from Selkirk shows an extremely high percentage of nitrogen in the first twelve inches, and in the second twelve inches as high a percentage as in ordinary pasture surface soil. Lastly, both the first and second twelve inches of the soil from Winnipeg are shown to be very rich in nitrogen—richer than the average of old pasture surface soil.

The question arises, how far the nitrogen in these soils is susceptible of nitrification and so of becoming easily available for vegetation? The soils and subsoils are placed in shallow dishes,

covered with plates of glass, kept under proper conditions of temperature and moisture for specified periods, extracted from time to time, and the nitric nitrogen determined in the extracts.

The periods were never less than twenty-eight days, and sometimes more. The rate of nitrification declined after the third and fourth periods. There was a very marked increase in the rate of nitrification in the subsoils during the eighth period compared with the seventh, there having been added only as much as the tenth of a gram of garden soil containing nitrifying organism.

This result is of much interest, affording confirmation of the view that the nitrogen of subsoils is subject to nitrification, if only under suitable conditions, and that the growth of deep-rooted plants may favour nitrification in the lower layers.

Records show that the rich prairie soils of the Northwest are competent to yield large crops; but, under existing conditions, they certainly do not on the average yield amounts at all commensurate with their richness compared with the soils of Great Britain, which have been under arable cultivation for centuries. That the rich prairie soils do not yield more produce than they do, is due partly to climate but largely to scarcity of labour, and consequent imperfect cultivation, and to luxuriant growth of weeds; and until mixed agriculture, with stock feeding, can be had recourse to, and local demand arises, the burning of the straw, and deficiency or waste of manure, are more or less inevitable, but still exhausting practices. So long as land is cheap and labour dear some sacrifice of fertility is unavoidable in the process of bringing these virgin soils under profitable cultivation; and the only remedy is to be found in the increase of population. Still the fact should not be lost sight of, that such practices of early settlement, however unavoidable, do involve serious loss of fertility.

A table has been prepared showing the comparative characters, as to percentage of nitrogen and carbon, of exhausted arable soils, of newly laid down pasture and of old pasture soils, at Rothamsted, also of some other old arable soils in Great Britain; of some Illinois and Manitoba prairie soils; and, lastly, of some very rich Russian soils. A comparison of the figures leaves no doubt that a rich virgin soil, or a permanent pasture surface soil, is characterised by a relatively high percentage of nitrogen

and carbon. On the other hand, soils which have long been under arable culture are much poorer in these respects; while arable soils under conditions of known agricultural exhaustion show a very low percentage of nitrogen and carbon, and a low relation of carbon to nitrogen.

In conclusion, the authors said that it had been maintained by some authorities that a soil was a laboratory and not a mine; but not only the facts adduced by them in this and former papers, but the history of agriculture throughout the world, so far as it was known, clearly show that a fertile soil is one which had accumulated within it the residue of ages of previous vegetation; and that it had become infertile as this residue was exhausted.

V. The Geognosy of Crystalline Rocks.*

By T. Sterry Hunt.

The author discussed at length the relations of the great masses of crystalline rocks usually divided into stratified and unstratified, and considered the intrusion of the latter, both in a plastic state among harder rocks, and in the form of resisting solids among softer and yielding materials. He then proceeded to notice the view held by many of the older geologists, and still entertained by some, that the laminated structure in crystalline schists is no evidence of aqueous deposition, but is developed by movements of translation in a plastic igneous mass. While maintaining for most stratiform rocks an origin by aqueous deposition, he showed that such a structure is also developed in many cases by movements during the extrusion of exotic rocks, and sought to define its conditions.

As regards the source of such rocks, it is argued that granites and some related aggregates are (in accordance with the crenitic hypothesis elsewhere advocated by the author) of secondary origin, and previous to their displacement had been formed from a primary plutonic mass, mediately, through the action of water solvents. A larger portion of exotic rocks, however, comes immediately from this primary mass, which was itself from an early

* Abstract of a paper read before the Royal Society of Canada at Ottawa, May 28, 1885.

time penetrated by water, and has furnished directly the chief part of the basic eruptive rocks of various geological ages. This primary plutonic stratum was considered as modified from without by additions and subtractions through permeating waters, and also interiorly by differentiations, through a process of segregation, which has probably been at work from a remote period. This was illustrated by the slow crystallization from fused silicated mixtures of species such as chrysolite and magnetite, which are heavier and less fusible than the parent mass. From such partially crystallized mixtures, a separation by eliquation may take place; and thus unlike, and more or less basic, portions may be derived from a once-homogeneous plutonic mass. Evidences of some such process are afforded in the variations to be seen in undoubtedly exotic basic rocks, which often present mineralogical differences in contiguous portions, having a stratiform arrangement due to movements of flow in extravasation. Phenomena of this kind, which the author had formerly ascribed to the partial intermingling by fusion of masses originally distinct, he now conceives to be due to partial separation by the above-described process, the importance of which, in the history of igneous rocks, was long since recognized by Durocher.

The limitations of such a process of differentiation by crystallization and eliquation, and the distinction to be drawn between exotic masses, occasionally stratiform in their internal arrangement and aggregates—whether in veins or in beds—of direct crenitic origin, was insisted upon. The great extent and the importance of certain crenitic masses deposited in fissures as veinstones, and often distinctly stratified, was noted, and it was maintained that a neglect to distinguish between these and exotic rocks has been the source of much error and confusion among observers, who, by confounding two kinds of mineral masses of unlike origin, have obscured instead of elucidating important geological problems. The study of such masses belongs primarily to the chemist and the mineralogist.

VI. A New Genus of Cambrian Pteropods.

By G. F. Matthew.

The hyolithoid pteropods of the St. John group present several different types of structure, of which, perhaps, the most interesting and instructive, as regards genetic relationship, is the one I propose herein to describe.

In the investigation of some points of structure in these species of pteropods, the writer has been favoured with the assistance and advice of Prof. Alpheus Hyatt, of Boston, a gentleman who has given much time to the investigation of the structure and affinities of the Cephalopoda, and is, therefore, well qualified to define the relationship of that class of animals to the pteropods in question. Professor Hyatt's conclusions, after an examination of these fossils, is that they are not Orthocerata, but are pteropods allied to Hyolithes, though with the unusual feature of transverse septa shutting off chambers at the bottom of the tube. Since they were submitted to Professor Hyatt, other individuals of some of the species have been obtained, which exhibit an earlier or larval condition, represented by a narrow tube, which is analogous to the embryonic or larval tube or prosiphon of the Cephalopods, as described by several authors. The simple camerated species I propose to describe, under the name of

Camerotheca.

Slender oval or transversely oval cones with attenuated apices. In the lower (smaller) part of the tube, or cone, there are septa that divide off segments of the tube from the body cavity (chamber of habitation). In most species, this septate portion of the cone is prolonged towards the apex into a narrow attenuated tubule formed during the earliest stage of growth; the tubule is divided by transverse diaphragms (?) at regular intervals, and is more or less flexible.

In these shells there is added to the ordinary body cavity of Hyolithes, two spaces or regions showing antecedent conditions differing from that manifested by the ordinary thecoid pteropod of the Cambrian and Silurian systems. The first may be designed as the larval region, and is, perhaps, most instructively exhibited in a species (*Diplotheca hyattiana*, n. gen. et sp.,) which from its subsequent development falls in another genus. The tubule in this

species is in the condition of a flexible whip or tail, and as preserved in the shale it is not unfrequently twisted from the plane in which the principal part of the shell is flattened, and it is also frequently bent away from the axial line of the cone to the right or left. In some cases, the larval region of *D. hyattiana* is preserved in the shale as a flattened cylinder; in others, as a very slender, slowly-expanding tubule; but in all cases it is crossed by distinct annulations about as far apart as the tube is wide, and of a firmer texture than the interspaces. Whether the projection of these nodes is due to a thickening of the tube, or to transverse diaphragms within, does not clearly appear, but the latter alternative seems the more probable one.

The mucronate point in which the apex of most species of Hyolithes terminates, may be seen to have been formed in the upper part of the larval region in some specimens of *D. hyattiana*; but others have not got it. This variation of the presence or absence of the mucronate point at the top of the larval tubule, shows how and where the thickening or calcification of the shell began, and renders it probable that all of the Hyalithoid shells began in a similar larval tube, but that in most of them the tube became deciduous, or was absorbed.

The possession of a septate region is perhaps the feature by which this genus of pteropods can most readily be recognised, or at least separated fron the ordinary Hyolithes. This region is well shown in two species of this genus, *C. gracilis* (n. sp.), and *C. daniana* (*Hyolithes danianus*, Bulletin No. 10, U. S. Geological Survey). It is marked by a more or less rapid expansion of the cone, by added firmness of texture in the shell, and by the presence of several transverse septa, crossing the cavity of the shell. The chambers thus produced are not known to be connected by a siphon. This part of the shell, as preserved in the shale, is always more terete than the rest; owing either to its firmer outer shell, or to the support given by the septa, or to a more perfectly rounded contour during the life of the occupant.

In the species of this genus, the conical shell expands less rapidly above the septate space than in it. *C. gracilis* (n. sp.) may be taken as the type.

The modern genus *Cuvieria* possesses a septate shell which has some features in common with Camerotheca, but the lower part

of the body-cavity is more ventricose, and the lower chambers formed by the septa at the apex are broken away, or from other causes are wanting. *Phragmotheca* of Barrande comes nearer the St. John genus in time, being of Upper Silurian age, but as it is classed by some authors as a sub-genus of *Pterotheca* it is evidently widely different from the slender cones of the genus *Camerotheca*.*

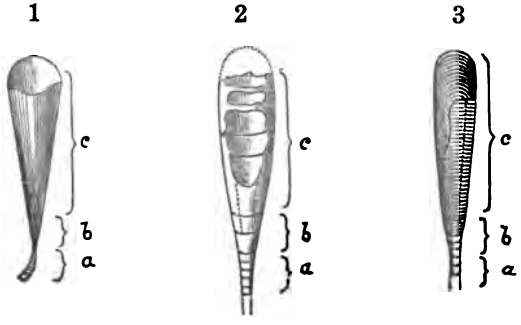
In the three phases of growth through which these pteropods passed some interesting affinities are suggested. Professor Hyatt in his article on the Fossil Cephalopoda read at the Minneapolis meeting of the American Association, 1883, concludes from his study of this group of animals that the prototype of the mollusca must have had a "globose embryo attached to the apex, the apex composed of a living-chamber opening into the protoconch, or globose shell of the embryo, without septa, though possibly divided more or less by diaphragms. Diaphragms precede the formation of the septa in the embryo Ammonoid. This confirms Von Jhermig's opinion that Tentaculites was the prototype of the Cephalopoda, since it has similar embryo and diaphragms. The prototype of the sub-classes *Tetrabranchiata* and *Dibranchiata* must have been a form of the same type, with, however, only a single septum or series of septa, having closed cœca in place of a siphon."

In these words we have almost an exact description of the larval and septate regions of the shell of *Camerotheca*, a genus which, originating earlier than *Tentaculites*, is more likely to have been connected with the ancestors of the Orthoceratidæ.

Finally, I may remark that the form of the apex of the Gasteropods of the St John group belonging to Division 1 (the portion of the formation containing the Acadian fauna) is a straight tubule similar to those we have described, though much shorter in proportion to their size, and apparently devoid of diaphragms.

* At the time of writing the above description of Camerotheca, I had access only to the generic description of Hyolithes, in which no reference is made to the occurrence of septa in the tube. Since then, however, I have seen the specific description of Eichwald's typical species *H. acutus*, from which it appears that this species had one of the important characters of Camerotheca, viz., septa near the apex of the tube. It will therefore be necessary to place Camerotheca as a sub-genus of Hyolithes, characterised by its elongated form and attenuated and flexible apex.

The accompanying figures represent the three species referred to in this article:—



No. 1. *Diplotheca hyattiana* var. *caudata*, $\frac{3}{1}$, with larval tube or prosiphon.

No. 2. *Camerotheca daniana* with larval tube and septa above.

No. 3. *Camerotheca gracilis* (immature).

a. is the larval region or space, having a thin flexible tube with diaphragms.

b. is the septate region, with thicker shell and septa sometimes calcified.

c. is the body-cavity or chamber of habitation.

VII. Meteorological Observations for 1884.

By C. H. McLeod.

The table on the succeeding page is an abstract of the meteorological observations made in 1884 at the McGill College Observatory, Montreal. The Observatory is situated at the height of 187 feet above the level of the sea.

The greatest heat was 91.0 on August 21st; greatest cold was 23.5 below zero on Dec. 20th; extreme range of temperature was therefore 114°.5. Greatest range of the thermometer on one day was 37.6 on May 2nd; least range was 4.0 on Nov. 28th. The warmest day was Aug. 21st, the mean temperature being 81.15. The coldest day was Dec. 20th, mean temperature 17.3 below zero. The highest barometer reading was 30.964 on January 27th, the lowest 28.960 on January 9th, giving a range of 2.004 in. for the month and year. The lowest relative humidity was

TABULAR SUMMARY.

Month.	Thermometer.				*Barometer.				†Mean pressure of vapour.	‡Mean relative humidity.
	Mean	Max.	Min.	Mean daily range	Mean.	Max.	Min.	Mean daily range		
January.....	8 73	40.5	—16.5	16.38	30.0109	30.964	28 960	.3353	.0634	81.12
February...	18.11	44.0	—11.0	17.52	30 0027	30.686	29.175	.3649	.0956	85.59
March.....	25.65	47.1	— 9.4	14.02	29 9941	30 395	29.518	.2350	.1212	79.69
April.....	40.55	69 0	24.5	14.17	29.8369	30.317	29.233	.1635	.1794	71.68
May	51.95	75.9	33.5	17.92	29.8859	30.266	29.438	.1721	.2751	68.55
June	66.91	86.0	44.0	21.00	30.0187	30 565	29.584	.1544	.4478	67.00
July	65.84	86.7	51.0	16.48	29.7783	30.073	29 445	.1326	.4826	75.98
August	68.79	91.0	43.8	17.84	29 9733	30.348	29.569	.1227	.5006	71.05
September...	61.76	87.7	36.5	16.07	29 9859	30.530	29.487	.2163	.4160	73.09
October.....	44.96	70.6	23 9	13.28	30.0393	30.623	29.573	.2557	.2427	76.41
November..	30.34	49.8	13.2	13.45	29.9683	30.451	29 311	.2878	.1393	79.96
December....	16.51	49.0	—23 5	13.57	30.1140	30 836	29.204	.2932	.1007	85.99
Means for 1884	41.675	.....	.....	15.975	29.9696	.....	.....	.2278	.25537	76.342
Totals	.....	.....	.....	.....	.....	.....	.....	.....	.....	....
Means for 10 years ending Dec. 31, 1884.	42.113	.....	.....	.....	29 9746	.....	.....	.....	.25275	74.225

Month.	Wind.		Sky clouded p. ct.	Percentage of possible sunshine.	Inches of rain.	Number of days on which rain fell.	Inches snow.	Number of days on which snow fell.	Inches rain and snow melted.	Number of days on which rain and snow fell.	Number of days on which rain or snow fell.
	Mean direction.	Mean velocity in miles p. h.									
January....	S.W.	12 23	66.4	27.6	0 22	3	44 2	21	4.38	2	22
February..	W.S.W.	9.98	75 8	22.4	2 18	9	29.3	20	4.95	6	23
March	W.S.W.	11.41	56 2	47.6	1.32	7	20.9	14	3.39	2	19
April	N.W.	9.33	68.2	33.7	2.09	10	3.9	6	2.48	1	15
May	W.S.W.	9.84	70 3	43.8	3·51	19	0 0	0	3.51	0	19
June.....	S.W.	8.99	45.7	68 8	3·38	9	0 0	0	3.38	0	9
July	W.S.W.	9.61	59.5	46.4	4·73	19	0.0	0	4.73	0	19
August...	W.S.W.	8 35	39.9	67 1	1·75	7	0 0	0	1.75	0	7
September.	W.S.W.	9.87	44.7	58.9	3 37	11	0.0	0	3.37	0	11
October	W. by S.	9.72	73.6	33.2	2·62	17	0.5	5	2.67	3	19
November.	S.W. by W.	11.15	72.9	27.6	2 13	12	5.0	10	2 62	3	19
December.	W.S.W.	11.81	64.3	22.4	1·53	8	35.0	14	4.57	1	21
Means for 1884.....	W.S.W.	10.191	61.46	41. 8	.....	.....	....	....	.....	.....	.....
Totals	.....	.....	.....	.....	28.83	131	138.8	90	41.80	118	203
Means for 10 years ending with Dec. 31st, 1884.	W. by S.	10.935	60.99	§46.92	27 27	136.5	116.6	85.3	38 91	15.9	211.7

* Barometer reading reduced to 32° Fahr., and to sea level. †Inches of Mercury. ‡Relative saturation being 100. § For three years only. The monthly means are derived from observations taken every 4th hour, beginning with 3.08 a.m.

23 on April 26th. The greatest mileage of wind recorded in one hour was 59 on May 2nd, when the velocity in one gust was at the rate of 80 miles per hour. (This is the greatest velocity ever recorded here.)

The sleighing of the winter closed on April 1st. The first appreciable snow of the autumn fell on October 25th, but melted as it fell. The first sleighing of the winter was on Nov. 29th. Upper river navigation opened April 17th. Ferries were running on April 22nd. River open to ocean ships on April 27th. First ocean ship arrived in port on May 2nd.

Auroras were observed on 21 nights. Hoar frost on 23 days. Fogs on 13 days. Lunar halos on 8 nights; Lunar corona on 2 nights. Thunder storms on 12 days, and lightning without thunder on 6 days.

The red sky at sunrise and sunset was very brilliant in January and February. It has decreased in brightness, but has been observable up to the end of the year.

VIII. Notes on the Geology and Fossil Flora of Prince Edward Island.*

By Francis Bain and Sir William Dawson.

[In the Canadian Naturalist, the predecessor of this Journal (Vol. IX, No. 9, New Series), Mr. Bain published some notes on the geology of Prince Edward Island; and the following additional note is intended to be supplementary thereto, and to refer more especially to the evidence of fossil plants in relation to the arrangement of the formations of the Island previously proposed by Mr. Bain.]

The rocks of Prince Edward Island seem to me to be divisible on the evidence of superposition and fossils into three sections, as follows.—

First.—The lower series of grey, brown, and red sandstones and shales, termed by Sir William Dawson Permo-Carboniferous presenting a thickness of about 800 feet. This series contains all the more decidedly Carboniferous plants found on the Island,

*Communicated to the Royal Society of Canada at its meeting in Ottawa, May, 1885.

as *Calamites suckovii*, *C. cistii*, *C. cannæformis*, *Dadoxylon acadianum* and *Trigonocarpum*, associated, however, with plants of a Permian character.

Secondly.—A middle series, reposing conformably, or nearly so, on the last, and consisting of 2,000 feet of red sandstones and shales,—the shales, and also calcareous sandstones, predominating in the lower part. This series is distributed over the greater part of the Island. It is of greatly reduced thickness in the western parts. It contains plants of a decidedly Permian character, as Walchia, *Calamites gigas*, *Pecopteris arborescens*, great numbers of stems of Araucarites evidently allied to Walchia, and the impressions of large, thick leaves that look like Noeggerathia, with *Dadoxylon edvardianum* of Triassic affinity. The beds are disturbed slightly by three lines of anticlinal, running parallel with the Cobequid range of mountains. The disintegration of the great shale beds of the lower part of this series has caused the separation of Prince Edward Island from the mainland. At what appears to be the summit of the series is a bed of quartzose conglomerate, which is pretty extensively distributed, being found in the synclinal on the Murray Harbor road, about the head waters of North River, and other localities in the centre of the Island.

Thirdly.—A horizontal series of red sandstones and shales, not distinguishable lithologically from the last, except it be by more regular bedding, and appearing to repose unconformably on the denuded strata of the most northern anticlinal of the Permian. Greatest thickness observed, 150 feet.

So far as yet ascertained, the plants found in this series are mostly specifically distinct from those of the lower rocks. But there is a generic relationship, especially with those of the middle series. This is seen in the few better preserved specimens, and also in the numerous fragments and obscure markings. Adding to the general specific distinctness of its plants the fact, that this series yielded the remains of *Bathygnathus borealis*, we are inclined to consider it the representative of the Triassic. Its beds are best seen on the north shores of the Island, about New London and eastward; but their exact distribution is very difficult to determine, owing to their general conformability to the underlying Permian. A good and typical exposure of this series occurs at Cape Turner on the north shore of the Island.

The rocks at Cape Turner belong to a horizontal series of strata which stretches along the north shore from New London to Tracadie Harbor, lying unconformably on a denuded anticlinal of the Permian, at least they occupy the place where we ought to find indications of the eastward extension of the Tryon anticlinal. The Report of Drs. Dawson and Harrington, 1871, states that at Tryon appears to be "the beginning of a synclinal." At Campbell's Cove I found the centre of the anticlinal, the beds dipping both ways from it. To the west its influence can be traced for a considerable distance on the Irish Town Road, though not seen at Darnley and its vicinity; but, eastward it is lost under the horizontal series mentioned.

This Cape Tryon anticlinal is the third of a series parallel to the Cobequids, which disturbs our Island beds. Two have been mapped out in the Report above referred to, and this third and most distant one, though irregular and broken, is of great interest.*

The horizontal beds of Cape Turner, I think, must be called truly Triassic. Their westward extension into New London contained the Bathygnathus, and all the remains that I have found in them are dissimilar from those of the south side of the Island, except, perhaps, one doubtful fucus.

In looking at the little group of plants from Cape Turner it is to be observed, that while the groups from Gallas Point, St. Peter's Island, Miminigash, and localities on the south side of the Island all have a decided relationship among themselves, this Cape Turner group has no relationship to any of them. Even the fucoids of the Cape Turner beds are distinct, with, perhaps, one exception.

Remarks on the above by Sir William Dawson:—

The geology of Prince Edward Island, though somewhat simple, has been the subject from time to time of diverse opinions. It was natural that the earlier observers, influenced merely by mineral character and superposition, should relegate all the sandstone deposits, mostly of red colors, overlying the coal-measures of eastern Nova Scotia and extending across the

*See also Mr. Ells' Report, Geol. Survey of Canada, 1883–4.

Northumberland Strait into Prince Edward Island, to a "new Red Sandstone" formation, including in the geology of that time both the Permian and Triassic. As early, however, as 1842* the writer was able to announce the existence of Carboniferous fossils in these beds, and in 1845, in two papers published in the Journal of the Geological Society of London, to refer the whole of the Red Sandstone of the south side of Northumberland Strait and a portion of that of Prince Edward Island to the "Newer Coal formation," a name afterwards changed, in so far as the upper beds were concerned, to "Permo-carboniferous."

In 1871, in conjunction with Dr. Harrington, the writer instituted a geological examination of the whole Island, at the instance of the local Government, and published a report of fifty pages, with a map, sections, and figures of fossils. In this report were described and catalogued twenty species of fossil plants, of which sixteen were referred to the Permo-carboniferous and four to the Triassic. In the Report referred to, it was proposed to arrange the strata of the Island in two groups, Permo-carboniferous and Triassic, and to divide the latter into a lower and upper series, and in our map we limited the distribution of the former group to those regions in which it was distinctly characterized by infra-position and by fossils, thus leaving the greater part of the surface to appear as Triassic. Since 1871, Mr. Bain has been able to discover fossil plants of Permo-carboniferous types in several places in which they were not found by us, thus extending the range of that formation. These facts he published in the paper in the CANADIAN NATURALIST above referred to. More recently, he suggests a three-fold division of the beds, and would refer to Permian that part of the Series which we designated Lower Trias. Mr. Ells of the Geological Survey of Canada, who has recently re-examined the rocks of Prince Edward Island (Report of Survey, 1883-4), not only extends the limits of the lower series, but regards the Trias as very limited, and not clearly distinguishable from the Permo-carboniferous; but in this last respect I cannot but think he exaggerates the difficulty occasioned by the low dips of all the beds, and the strong mineral resemblance of the Trias to the underlying Permo-carboniferous, from whose disintegration it has undoubtedly been derived.

* Notes on Geology of Prince Edward Island, *Hazard's Gazette*.

The object of these remarks is, however, more especially to consider the testimony of the fossils recently collected by Mr. Bain when added to that previously obtained. On this I would remark:—

1. That the beds at Miminigash, Gallas Point, St. Peter's Island, Governor's Island, Rice Point and other places on the south coast, contain plants which elsewhere characterize the Upper Carboniferous and Lower Permian.

2. At certain points in the interior of the Island and in the bays of the north coast, which represent troughs between the Permo-carboniferous anticlinals, there are found plants indicating a higher horizon. Here the characteristic Carboniferous species are absent, and their place is taken by others, either Permian or Triassic. For example, the abundant coniferous wood of the Carboniferous species, *Dadoxlyon materiarium*, is replaced by an entirely different type more characteristic elsewhere of the Trias, *Dadoxylon edvardianum*. Some of the fossils found in this by Mr. Bain are undoubtedly of Permian aspect, as, for instance, the Walchias and *Calamites gigas*. Others, like the Dadoxylon above referred to and the curious *Cycadoidea abeqidensis* are undoubtedly more Triassic in aspect.

3. In the beds on the north side of the Island in which we found no well-characterised plants, but which afforded the remains of the Dinosaur, *Bathygnathus borealis*, Mr. Bain finds a few plants which he considers distinct from those in the lower beds. These must, I think, from their associations, be regarded as Triassic, though too few and imperfect to afford satisfactory terms of comparison with that formation elsewhere.

1. *Permo-carboniferous.*

The species catalogued from this formation in my Report of 1871, and my paper of 1874 in the Journal of the Geological Society of London, were the following:—

Dadoxylon materiarium, Dn.
Walchia gracilis, Dn.
" robusta, Dn.
Calamites suckovii, *Brongt.*
" cistii, Dn.
" gigas, Dn.
Neuropteris rarinervis, *Bunbury.*

Alethopteris nervosa, *Brongt.*
" massilionis (?), *Lesq.*
Pecopteris oreopteroides, *Brongt.*
" arborescens, "
" rigida, Dn.
Cordaites simplex, Dn.
Trigonocarpum, Sp.

To these Mr. Bain adds *Calamities cannæformis* or specimens very closely resembling that species, and stems of the genus *Tylodendron*, while he seems to think that Walchia of the type of *W. gracilis*, *Calamites gigas* and certain Noeggerathia-like leaves as well as the conifer, *Dadoxylon edvardianum* are more particularly Permian and characteristic of the second member above referred to.

Tylodendron was found by Weiss to include stems with elongate, prominent leaf-bases of the character of those of Knorria, but bifurcate at top. These stems or branches are very characteristic of the Permian of Russia, Germany and France. They have been found by Weiss to show the character of Dadoxlyon when the structures are preserved, and are therefore Coniferous; and it is now pretty generally believed that they are decorticated branches of Walchia.* So far as European evidence extends, they are to be regarded as strictly Permian, and the species drawn by Mr. Bain is not distinguishable from *T. speciosum* of Weiss. In Prince Edward Island, I have figured (Report, Plate III, Fig. 30,) what seems to be the same species, though under the name *Knorria* but my specimen may have been from the Middle Series, then called Lower Trias, but now regarded by Mr. Bain as Permian. In any case it is a strictly Permian form. The ferns of the Permo-carboniferous merit a careful re-examination in the light of recent publications in Europe and America.

2. *Permian and Triassic.*

The Walchia found by Mr. Bain in the second or Permian group is very near to my *W. gracilis*, and probably the same. Weiss has, however, described and figured in Germany,

* Flora der Rothliegenden in Saar-Rhein-Gebeite, 1872.

in a memoir published about the same time with my Report,* a species which he names *Walchia linearifolia*, and which is very near to *W. gracilis*, and especially to the variety of that species figured by Mr. Bain. Knorria-like stems and specimens of Sternbergia, obtained by Mr. Bain in the same beds, may all belong to this species. Large Noeggerathia-like leaves, such as those referred to by Mr. Bain, are not infrequent in the Permian elsewhere, and have been variously referred to ferns, to palms, and to taxine trees of the type of Salisburia. I have not seen Mr. Bain's specimens of these leaves.

Fig. 1. Branch of Walchia? Trias, Prince Edward Island. From a drawing by Mr. Bain.

The few plants collected by Mr. Bain in the Upper Trias, or Trias proper, are especially interesting in consequence of the paucity of well-preserved fossils in this formation. He finds in these beds a Calamites with very fine ribs of the type of *C. arenaceus*, and which may be an internal cast of that Triassic species, which, when perfect, is really an Equisetum rather than a Calamite; also certain Knorria-like branches different from Tylodendron but probably branches of coniferous trees (Fig. 1), and a species of Walchia apparently distinct from that of the lower beds. It has very stout and straight branches, marked with interrupted furrows. Its branchlets are long, slender and crowded, and at right angles to the branch. The leaves are closely appressed, triangular and scale-like. Detached branchlets have thus the aspect of the Mesozoic genus *Pachyphyllum*, but the

* I may remark here that I have obtained from the Permo-carboniferous of Cape John, on the Nova Scotia coast, a leafy branch with long parallel-sided obtuse leaves, and which may indicate a species of Ulmannia or Voltzia, but is not sufficiently perfect for precise description.

habit of growth is that of Walchia. The species is near to *W. imbricata* of the European Permian, but sufficiently distinct to deserve a name, and I have therefore called it *W. imbricatula* (Fig. 2).

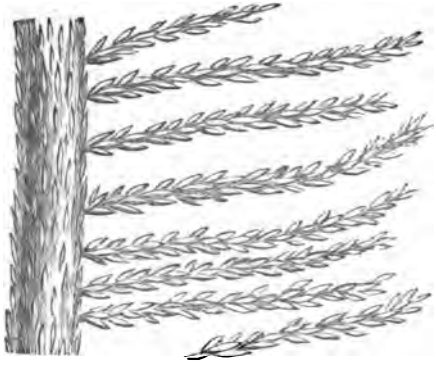


Fig. 2. *Walchia imbricatula*, S.N., Trias, Prince Edward Island. From a drawing by Mr. Bain.

It is to be observed that, in the red sandstones of Prince Edward Island, all the more delicate plants, and even twigs of coniferous trees, have completely lost their organic matter and are represented by mere impressions, stains, or casts in clay or sand, so that it is very difficult to ascertain their minute characters.

The general result, in so far as the subdivision of the beds is concerned, would seem to be that the lower series is distinctly Permo-carboniferous, that its extent is considerably greater than we supposed in 1871, that there is a well-characterised overlying Trias, and that the intermediate series, whether Permian or Lower Triassic, is of somewhat difficult local definition; but that its fossils, so far as they go, lean to the Permian side. The further researches of local observers like Mr. Bain may be expected to throw new light on these points, and to enable a more exact separation to be made of the several deposits.

IX. The Relation of Annual Rings of Exogens to Age.

By D. P. Penhallow.

That there is a certain relation existing between the well-known phenomenon of the development of rings of growth in exogenous trees and the age of the trees themselves, has been a matter of common observation and speculation for a very long time. Latterly, a few scattered observations have been made to determine this relation more exactly, but there appears to be nothing on record of a sufficiently systematic and exhaustive character to permit the deduction of a general law. The difficulties in the way of obtaining such data are considerable, one of the greatest being that of getting together a sufficiently large number of woods of different species, of which the exact ages are known. During the past year, somewhat unusual opportunities have been presented in this direction, and it has therefore been deemed desirable to collect all the data possible, and see how far they are in accord with the statements already made and the views generally held by botanists. The question may be considered as presenting itself under two aspects, viz:—

1st. Upon what does the distinction of rings depend?

2nd. Does every ring indicate one year of growth?

These primary considerations necessarily involve several others which it will be desirable to consider; but we will first pass in review the general opinions held at the present time, as also some of the more recent observations recorded.

It has been commonly accepted by botanists that each ring in the stem is generally determined by the annual cessation and renewal of activity, and that it thus corresponds to one full season of growth, and thus an estimate of the age of the tree may be obtained by counting the full number of rings. Schleiden gave expression to this view several years since.* More recently Gray† says: "Each layer being the product of a single year's growth, the age of an exogenous tree may, in general, be correctly ascertained by counting the rings in a cross section of the trunk." Bessey‡ is a little more explicit when he says that,

* Principles of Scientific Botany, 1849, p. 238.

† Text Book of Botany, p. 79.

‡ Text Book of Botany, p. 447.

"In cold climates they enable us to determine with accuracy the age of trees and shrubs." Again, Sachs* informs us that: "In woody plants, . . . that grow in a climate in which the periods of growth are interrupted by a cold or wet season, . . . the annual additions to the wood may be recognized as sharply concentric layers, known as *annual rings*."

These expressions, then, in which all agree in the main, may be taken as representing the prevailing view at the present time, and in confirmation of them we have certain facts cited from time to time by various writers and observers.† Mr. P. C. Smith ‡ cites cases in his own experience as a lawyer, where important legal decisions, involving large property rights, have been based upon a recognition of this relation; and he also calls attention to the exact correspondence found to exist between the subsequently developed rings of wood, and the time which has elapsed since surveyor's blazes were made on trees during the closing years of the last century. Similar testimony is also offered by Mr. J. A. Ferrer,§ as the result of his own observation.

On the other hand, however, Dr. A. L. Childs || brings forward important evidence to the contrary. He cites one instance where a shrub had developed as many rings as it was months old, and also states that, having planted seeds of *Acer rubrum* for the purpose of making an accurate test, at the age of twelve years he found the trees had developed from thirty-five to forty rings, or about three for every year's growth. Unfortunately, one very important item in this statement is omitted, since the locality is not given. Of the same nature, also, is the statement made by Dr. Warring¶ concerning *Chenopodium album*, in which he found that the plant had developed eight well-defined rings at the end of four months' growth.

The question also frequently arises as to how far the law of correspondence of rings to age will apply to trees of both temperate and tropical growth. With reference to this, Dr.

* Text Book of Botany, p. 132.

† Pop. Science Monthly, Vol. III, p. 321.

‡ *Ibid.*, Vol. XXIII, p. 552.

§ *Ibid.*, Vol. XXIV, p. 53. Vol. XII, p. 382.

|| *Ibid.*, Vol. XXII, p. 204.

¶ Amer. Jour. of Science, Vol. XIV, 1877, p. 395.

Warring* remarks that: "Trees in the tropics do form rings regularly, even when the conditions of growth are absolutely uniform, *e.g.*, mangroves growing on muddy margins of tropical rivers." He also endeavors to strengthen this view by citing the development of rings in the orange and lemon when grown in greenhouses, where the conditions are supposed to be subject to but slight variation all the year round. Sachs † remarks that "In tropical, woody plants, when several years old, the additions to the wood formed in each successive year are not generally distinguishable on a transverse or longitudinal section; the entire mass of the wood is homogeneous." And he very properly makes a distinction between such growth in warm climates and that where the alteration of seasons, and so of growth, is sharply defined. Dr. A. S. Baldwin‡ cites the case of a tree on his own ground in Florida, which was less than thirty years old when cut, but which exhibited very nearly forty rings of growth, and he infers from this and similar cases that the rings are determined by meteorological conditions, and represent periods of physiological rest and activity, which may be repeated whenever the external conditions are favorable.

STRUCTURAL CONSIDERATIONS.

An examination into the immediate cause of the distinction between contiguous rings of growth shows it to be of a two-fold nature and due (*a*) to localized deposition of coloring matter; (*b*) to structural peculiarities. In the cases of those trees which develop a large amount of resinous matter or of well-defined pigment this is often deposited in such a manner as greatly to facilitate distinct definition of the rings. In certain cases the color may be uniformly distributed throughout the entire structure; in other instances, as *Pinus* and to a certain extent lignum-vitæ, the deposition of the coloring matter is more strictly localized, and generally in that part of the structure formed at the close of the season's growth. The particular depth of color may arise from an actual deposition of pigment associated with resinous matter, as in *Pinus*, or from structural peculiarities which tend to in-

* Amer. Jour. of Science, 1877, p. 395. Acad. Nat. Science, 1878.

† Text Book of Botany, p. 132.

‡ Pop. Science Monthly, Vol. XXIV. p. 554.

tensify whatever color may be peculiar to the tissue as a whole; or it may arise from both these causes combined. This means of definition, however, is by far the least important, and may very properly be considered as subordinate to and serving only to augment those distinctions which arise from purely structural peculiarities.

In certain exogens it is to be observed that, in the growth of each year, the ducts and vessels are not uniformly distributed among the wood cells, but that there is often a very strong tendency for them to become localized, preponderating in that inner portion of the rings which represents the earliest growth of the season, thus forming a layer of more open and porous tissue, while the wood cells preponderate in the outer portions of the rings formed at the close of the growing season, and thus produce a much denser layer. This alternation of more or less dense structure, therefore, offers at once the means of clear and sharp distinction between contiguous rings, since the inner porous portion of each is directly opposed to the dense tissue last produced in the preceding ring. Moreover, this variation in density is not due alone to distribution of the ducts, but to variations in the size and aggregation of the wood-cells themselves, as will be seen in the next paragraph. Examples of this kind are to be found in varying degrees of development, in *Quercus*, *Corylus*, *Ulmus*, *Fraxinus*, *Castanea*, *Juglans*, *Rhus*, *Acer*, *Zanthoxylum*, *Tilia*, etc., of which we may well consider *Fraxinus* the type.

In other instances there is a marked absence of ducts and vessels, or, if present, they are so uniformly distributed that the entire structure becomes homogeneous and the distinction of rings is thus obliterated; and when rings do appear under such circumstances, their distinction must rest upon variations in the wood-cells themselves. Thus we find that those wood-cells which are first produced each season, are in cross-section relatively large, thin-walled, and more loosely aggregated; while those which are produced towards the close of the season are relatively small, thick-walled, closely aggregated, and often flattened in a radial direction. This variation often proceeds at a uniform rate towards the end of growth, or, as in *Alnus*, the transition from less dense to more dense structure is not unfrequently very abrupt. In any case, there is thus produced an apposition of more and less dense tissue,

which at once defines the rings, particularly if this denser aggregation involves a deepening of the color peculiar to the tissue as a whole. Examples of this we find very generally in the *Coniferæ*, *Populus*, *Alnus*, *Betula*, *Carpinus*, *Ostrya*, largely in *Fagus*, *Pirus*, *Amelanchier*, *Prunus*, etc.

In these respects, whenever rings are developed, tropical woods show the same characteristics as do those of temperate climates. Thus, from an examination of woods from Brazil, we gather the following data:—

Rings conspicuous	7
Rings imperfectly defined	4
Rings very obscure or none	10
Rings slightly defined structurally	4
Rings strongly defined by alternation of more and less dense tissues (ducts)	3
Rings defined by excess of color in first or last formed cells.	6
No structural distinctions, ducts uniformly distributed	11
Rings due to alternating growth and rest, ducts none, no obvious structural difference	5
Tissue dense throughout, rings numerous and variable	2
Outer rings broadest	2
Whole number of species	23

CAUSE OF VARIATION IN DENSITY OF STRUCTURE.

With regard to the immediate causes operating to produce variation in density of structure, the views of the earlier botanists have been very largely retained up to the present time. This variation was believed to be due primarily to alternating periods of activity and repose, as defined by the seasons; that the sharpness of definition and regularity of occurrence must be dependent upon the sharpness with which variable climatic conditions were separated and the regularity of their occurrence; and that whatever operated to interrupt a given period of activity, or introduce a new period of growth into one of rest, would strongly tend to modify the number of resulting rings. So that, while one ring might be the product of one season, it might, on the other hand, be the product of only a portion of the entire season's activity. Thus it naturally came to be considered that while in northern latitudes rings were an approximately exact index of age, they could not be so considered in more southern and tropical latitudes. These

views, as generally held, are well expressed by Sachs*, who also regards the alternation of density of structure as largely resulting from external pressure† exerted by the more resisting cortical structure, holding that the bark being relatively loose or of minimum tension in spring, the wood-cells first developed will therefore be larger and looser in structure, and the form least modified; but that as the tension constantly increases with continued development of new structure within, the cells must show a constantly increasing density and modification of form until, in the last of the season, the difference is very pronounced. In support of this view he also cites the experiments of H. de Vries ‡ by which the influence of external pressure in producing such modification is directly demonstrated. It would appear very doubtful, however, whether we are justified in assuming this tension of the cortical tissues to be the chief determining factor. If it were, then as the tension steadily increases towards the close of the growing season, there should be a correspondingly gradual change from the less dense to the more dense structure. But this does not always occur. Frequently the duct tissue ends abruptly, or, as we have seen, the ducts are uniformly distributed; there is an absence of ducts with uniform density in the distribution of the wood-cells, or, as in *Alnus*, the transition from larger thin-walled cells to those which are smaller and thick-walled may occur very abruptly at or near the close of growth for the season. Thus in the case of the tropical woods examined, sixteen out of the twenty-three appear to show that pressure of the bark is an unimportant factor, especially as eleven out of the sixteen show a regularity in distribution of the ducts through an otherwise uniformly dense woody tissue. In these woods, also, when rings are developed their distinction often rests—in five cases out of twenty-three—upon mere superposition of rings successively upon one another, without other structural difference, the lines of union or contract between successive layers thus becoming the means of distinction.

The general evidence here brought forward, therefore, seems to indicate, in many instances at least, a more or less close correspondence between the number of rings and the periods of

* Text Book of Botany, p. 652.

† *Ibid.*, p. 813.

‡ Flora, No. 16, 1872.

alternate repose and activity. Plants, like animals, seem to be incapable of continuous activity, but require periods of physiological rest and recuperation. Strict alternation of seasons secures and defines these periods, but where the climate is of a comparatively uniform character they must be secured by other conditions, as alternation of wet and dry periods, or possibly, also, by certain properties of the plant which are intrinsic; and this appears to be the explanation of the cases cited by Dr. Warring* of trees growing under uniform conditions and yet developing rings. We may thus state it as a general principle, that whatever tends to periodicity in growth, either from external or internal causes operates as a strong factor in the development of rings.

FACTS COLLECTED.

During the past year my friend, Mr. C. Gibb, removed the chief difficulty in the way of determining this question by placing at my disposal several trees, the ages of which were exactly known. Such an opportunity rarely occurring, it was at once taken advantage of, and the general results showing relation, of rings to age were found to be as follows :—

Subjects.	Age.	Rings clearly defined	Rings obscure.	Total Rings.
Salix regalis.....	7	5	2	7
European Silver Poplar.	6	6	....	6
Early Strawberry Crab..	11	10	....	10
Large Striped Crab.....	11	10	....	10
Quaker Beauty Crab.....	11	10	....	10
Re-exam. of stump lower down.	11	10	3	13
Golden Sweet Crab.....	11	10	....	10
Re-exam. of stump lower down	11	10	2	12
Pirus Coronaria.....	12	12	1	13
Gen. Grant Crab No. 1.....	11	7	5	12
Re-exam. of Stump lower down.	11	11	....	11
Gen. Grant Crab No. 3, close to ground.....	11	11	....	11
Gen. Grant Crab. No. 4, close to ground.....	12	12	....	12
Totals.....	136	124	13	137

Again, an examination of a large ash (*F. americana*), for correspondence between annual rings and the annual increase in length, gave the following results :—

* Amer. Jour. of Science, Vol. XIV, 1877, p. 395.

Branches.	(In length) Years Growth.	Rings well defined.	Rings poorly defined.	Total Rings.
No. 1	28	24	....	24
No. 2	16	16	...	16
No. 3	15	15	....	15
No. 4	18	18	....	18
No. 5	29	....	....	....
No. 6	31	....	....	....
No. 7	18	18	....	18
Totals	155	91	....	91

Of these, three showed a fairly close correspondence between thickness of rings and length of shoot for the same year. The figures of the first table show that of the thirteen examinations made, the following is the general summary of results:—

Whole number of examinations	13	....
Rings equal to age	5	38.4%
Rings exceed the age	4	30.8%
Rings less than age	4	30.8%
Totals	13	100.00

And, if we combine the results of the two, then we obtain as follows:—

Whole number of examinations	20	....
Rings equal to age	9	45.%
Rings exceed the age	4	20.%
Rings less than age	7	35.%
Totals	20	100.00

In most, if not all, of the cases in which the number of rings was found to exceed the age, this appeared to arise from the development of secondary rings, in which, while structurally defined, the definition was generally much less distinct than in the primary rings. Indeed they usually have the appearance of being strangers, and of having been produced by unusual causes.

The results show, however, that the probabilities are strongest in favor of correspondence between age and the rings of growth, and that while these latter may, and often do, exceed the former, there is greater probability of their being less, through want of structural definition.

We have next to consider the relation between rings and the meteorology for the corresponding year. It is first of all

observable that in many cases, the growth of the stem is not uniform upon all sides; or, in other words, a cross-section would show axes of unequal length and an elliptical section. In such cases, the major axis will be found in general to have the same compass bearings in all trees within a certain area where they are similarly influenced, thus indicating a common and prevailing force as operating upon them. This inequality of growth, as determined by my own observations, is often very considerable, in twelve cases ranging from 0.1 c.m. to 0.95 c.m. in stems not exceeding 9.5 c. m. in their greatest diameter, thus making the maximum inequality equal to $\frac{1}{10}$ of the diameter itself. A very good case of this kind has been cited by Mr. T. S. Gold,* as occurring under his immediate observation. This irregularity of growth is well known to be due, as Sachs has shown,† to the action of the wind, which, swaying the tree back and forth, causes an alternating release of tension in the tissue of opposite sides of the stem. This release of tension necessarily tends to accelerated growth in the subjacent tissues, and thus unequal growth results, the major axis of which will coincide with the direction of the prevailing winds. Assuming the longitudina growth of the axis to bear the same relation to meteorological conditions as the growth in diameter, the following comparison for twelve years' growth of *Fraxinus americana* will be of interest:—

RELATION OF GROWTH IN LENGTH TO METEOROLOGY.

Years.	1	2	3	4	5	6	7
1883.....	3.90	11.50	6.40	13.10	2.50	3.70	9.60
1882.....	3.50	5.70	4.15	7.15	2.60	3.70	6.00
1881.....	5.30	7.25	5 35	7.50	3.00	4.60	9.90
1880.....	3.00	4.18	4.45	5.70	2.35	3.10	9.35
1879.....	3.00	5.40	6.35	4.10	2.60	2.55	11.50
1878.....	1.50	3.50	3 00	2.30	1.75	2.00	4.60
1877.....	1.90	3.35	4.00	2.10	2.30	1.90	4.00
1876.....	2.25	7.85	7.35	4.10	3.75	2.90	10.10
1875.....	2.35	6.95	9.05	6.90	3.70	4.00	19.30
1874.....	3.25	7.70	14 70	11.20	3.90	4.60	16.50
1873.....	1.95	13.10	13.30	12.50	3.15	3.20	27.50
1872.....	4.15	8.80	11.10	7.35	4.20	3.00	25.40

* Pop. Science Monthly, Vol. X, p. 379.

† Text Book of Botany, p. 813.

RELATION OF GROWTH.—*Continued.*

YEARS.	Sums.	Means.	Rain.	R. H.	Temp. O°F
1883.....	50.7	7.24	20.38	71.6	61.1
1882.....	32.8	4.68	18.40	69.1	61.2
1881.....	42.9	6.15	11.95	69.9	64.2
1880.....	32.7	4.65	15.85	68.1	64.3
1879.....	35.5	5.07	14.95	69.9	62.0
1878.....	18.7	2.66	16.40	69.1	64.6
1877.....	19.6	2.79	11.62	68.2	64.5
1876.....	38.3	5.47	18.51	73.0	63.0
1875.....	52.3	7.47	19.77	73.9	61.8
1874.....	61.8	8.83	14.35	70.2	61.5
1873.....	74.7	10.66	14.19		67.0
1872.....	60.0	8.57	14.00		65.0

In the table on the following page comparison is made with the thickness of rings for each year. The thickness of each ring as given is the mean of the thickness measured in cross diameters, and thus of four measurements in each case; and the mean of several rings for the same year, from different trees, should enable us to trace whatever connection there may be between growth and meteorological conditions. There is one element here, however, which tends to impair the accuracy of such a comparison, and makes it only indicative. In bringing the same years of growth together, it necessitates comparing the rings of a younger generation of growth with those of an older generation, *e. g.*, the Gen. Grant Crab No. 1 was eleven years old when cut in 1883; the European Silver Poplar was six years old at the same date, and therefore, in comparing the growth in the two for 1883, the sixth generation of the latter is necessarily brought into comparison with the eleventh generation of the former, and this tends to inaccuracy, since each generation or each ring, does not involve variations dependent upon meteorological conditions alone, but upon cycles of physiological change, as will be seen shortly. In our comparisons, therefore, this must be kept clearly in mind and due allowance made.

* Measurements in centimeters. Meteorological means for five months, May to Sept., inclusive.

Comparative Table of Meteorology and Annual Growth by Rings.

Subjects.	1883	1882	1881	1880	1879	1878	1877	1876	1875	1874	Means
Relative Humidity	1.60	.70	.90	.90	.80	.90	.90	.00	.90	.20	.84
Precipitation	20.38	.84	.91	.81	.79	1.10	1.10	1.31	1.13	1.11	1.24
Mean Temperature	71.10	71.20	71.20	71.40	71.00	71.00	71.00	71.00	71.00	71.00	71.00
Salix regalis	1.50	0.60	0.400	0.200	0.200	0.100	0.100	.....	.....	.....	0.500
Gen. Grant Crab No. 1	0.600	0.010	0.120	0.050	0.200	0.000	0.000	0.000	0.000	0.000	0.220
" " " No. 2	0.300	0.200	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.100
" " " No. 3	0.200	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
" " " No. 4	0.800	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400	0.400
European Silver Poplar	1.400	0.700	0.500	0.300	0.200	0.000	.....	.....	.....	.....	0.650
Early Strawberry Crab	0.400	0.100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Large Striped Crab	0.100	0.500	0.400	0.400	0.200	0.100	0.100	0.200	0.000	0.200	0.200
Aiken Stripe Winter Crab No. 6	0.000	0.100	0.000	0.000	0.000	0.000	0.200	0.200	0.200	..	0.200
Quaker Beauty Crab No. 1	0.100	0.200	0.000	0.000	0.000	0.000	0.200	0.200	0.000	0.000	0.120
" " " No. 2	0.900	0.500	0.500	0.500	0.400	0.500	0.200	0.200	0.000	0.000	0.400
Golden Sweet Crab No. 1	0.600	0.100	0.100	0.200	0.500	0.500	0.500	0.500	0.500	0.500	0.350
" " " No. 2	0.600	0.500	0.300	0.200	0.500	0.400	0.200	0.500	0.400	0.500	0.340
Pirus coronaria	0.500	0.500	0.400	0.400	0.000	0.000	0.400	0.200	0.000	0.200	0.270
	0.724	0.401	0.404	0.378	0.380	0.371	0.284	0.220	0.311	0.300	0.404

Met. for 5 months, May to Sep., inclusive. Rain in inches. Temp. 0°F L.M. - 0 M.

TABLE COMPARING RINGS AND METEOROLOGY.

The most exact results, such as I hope to obtain as soon as another opportunity offers, would be secured by the use of a planimeter to determine the area of each separate ring of growth, and from that its mean thickness. The circumstances of the case, however, necessitated less exact methods.

In the course of these examinations, it has been observed incidentally that the rings of growth show a regularity of increase or decrease in thickness which is quite independent of those variations previously referred to. In other words, the first formed layers are thinnest or thickest, and those subsequently formed either steadily increase or diminish in thickness with each succeeding year, and thus there is produced what may be termed the curve of accelerating or diminishing growth, which is quite independent of the waves representing annual variations from other causes.

Examining our specimens in this direction it was found that of the eleven tropical woods forming distinct rings, the innermost rings were broadest in two cases, while in the remaining nine there appeared to be uniformity of thickness throughout. An examination of thirty-five native Canadian woods gave the following:—

1. Central rings broadest	10
2. Outer rings broadest	11
3. Cycles of increase and diminution	3
4. Rings uniform throughout	11
	35

The first case, in which the rings steadily decrease in thickness from the centre outward, is illustrated in *Tsuga canadensis*, *Betula nigra*, *Ulmus fulva*, *Fraxinus sambucifolia*, *Amelanchier canadensis*, *Prunus americana*, *Rhus typhina*, *Acer dasycarpum*, *Zanthoxylum americanum*, and *Tilia americana*. The second case, in which the rings continually increase in thickness with each year of growth, is illustrated in *Picea nigra* and *alba*, *Pinus resinosa* and *strobus*, *Thuya occidentalis*, *Abies balsamea*, *Quercus rubra*, *Corylus rostrata*, *Fagus ferruginea*, and *Pirus americana*. From what has been observed in other cases, it seems highly probable that, had the specimens been of sufficient age, this continued increase in thickness would have been succeeded by as regular a diminution, thus bringing these eleven cases in

reality in the next division. The third case, in which the rings first increase continually in thickness, and, later, as regularly decrease, is illustrated in *Betula alba*, *Ostrya virginica*, and *Fraxinus americana*. The fourth and last case, in which the rings are all of more uniform thickness, is illustrated in *Populus tremuloides* and *grandidentata*, *Alnus serrulata*, *Betula lutea*, *Carpinus caroliniana*, *Juglans cinerea*, *Ulmus americana*, *Fraxinus viridis*, *Prunus serotina*, *Acer rubrum* and *saccharinum*.

CONCLUSION.

I hardly feel justified in drawing decisive conclusions from evidence of so limited a character, but the facts here stated furnish certain indications which it may be well to state as a guide to future and confirmatory observations. They are as follow:—

(1) The formation of rings of growth is chiefly determined by whatever operates to produce alternating periods of physiological rest and activity. In temperate climates, where the seasons are sharply defined, these periods are determined by the seasons themselves, but in tropical and sub-tropical latitudes other influences, recurring at less regular periods, operate to determine them, therefore—

(2) In cold climates, rings of growth are an approximately correct index of age, but in warm climates they are of little or no value in this respect.

(3) Even in cold climates there is not an absolute correspondence between number of rings formed and years of growth.

(4) In warm climates the tendency is to obliteration of rings and homogeneity of structure.

(5) The distinction of rings is essentially due to structural modifications, sometimes aided by local deposit of pigment or resin, and this modification of structure is due in part to pressure of the external structure upon the forming tissues, and, in part, to physiological peculiarities of the plant itself as independent of such presence.

These indications are thus seen to be essentially in accord with the views generally held at the present time, as already stated.

(6) The influence of meteorological conditions in determining the growth of each season is most important, particularly with reference to rainfall.

(7) Periodicity in rainfall corresponds with periodicity in growth.

These general relations are very manifest in the chart,* both in the formation of rings and elongation of the axis. In the first case it will be seen that the period of accelerating growth extends over the first eleven years, and at the end of that time does not appear to be fully completed. In the second case, the period of diminishing growth is found to occur during the earlier years of development and reaches its minimum in six years, when it is followed by the period of accelerating growth during the remaining five years out of the eleven over which observations extended.

X. Montreal Botanic Garden.

We are in receipt of a circular from the Board of Management of the Botanic Garden, setting forth in brief terms the object to be accomplished and the amount of money required, for which an appeal is made to the generosity of the citizens as follows:—

"The Act obtained, Quebec, Vict. 48, Chap. 63 provides: Sec. 1, that the Corporation shall consist of seven persons elected from the Horticultural Society, and such other persons as shall donate sums of money not less than $100 each. Also, Sec. 5, that all donors shall be entitled to one vote at all meetings of the Corporation, but the latter may have the power to give additional votes for each additional $100 subscribed. It further provides, Sec. 7, that the affairs of the Corporation shall be managed by a Board of Management, composed of five members elected from the Corporation, one of the said Board to be the Director of the Garden. Also that there shall be a Secretary and Treasurer or Secretary-Treasurer.

"Through the generous assistance which the friends of the project have given, a grant of $1,000 for preliminary work has been obtained from Quebec, and it is hoped that an annual grant may be secured from the same source. It is also believed that a work of such eminent public utility, appealing, as it does, to wide and important national interests, will also commend itself so fully to

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* The chart showing these relations in curves was unavoidably omitted. [Ed.]

public consideration that we may secure a grant from the Dominion Government at Ottawa.

" From the city of Montreal we have the promise of such land as will answer the needs of the Garden. The boundary lines have already been located, and only await ratification by the Council.

" The tract of land selected embraces about seventy-five acres, extending from Park Avenue to the base of the mountain, and from the land of Mr. J. H. R. Molson to the Park boundary on the west. The location is the most favorable that could have been selected within easy distance of the centre of population. It will be easy of access, and it is central to all the educational interests of the city, while a fine garden in such a place, will tend to draw a good class of citizens in that direction, and thus cause the erection of dwellings along now unoccupied streets.

" In its natural advantages of soil and resources the location is a very favorable one. The soil is rich and the surface diversified, permitting ample scope for the development of fine landscaping effects. There are several buildings already on the ground which will be made the best use of. There are also, within the limits of the tract, three natural springs, which will afford an unfailing supply of pure water.

" It is designed to devote a certain portion of the land to the purpose of an arboretum, in which may be grown hardy trees and shrubs from all parts of the world, our own included. A smaller portion of the tract will constitute the garden proper, in which will be collected all the herbaceous plants, arranged in their natural order and properly labelled, which can be grown here. These will be collected from all parts of the world. As an important feature of the Garden, there will be glass-houses for the growth of tender exotics, and buildings to contain the offices, library, and museum of economic vegetable products. As resources and opportunity permit, investigations will be instituted concerning the care and treatment of forests, the prevention of disease and other important questions affecting the commercial prosperity of the Dominion through its forests and orchard industries.

" In its relations to educational interests, it is designed that all the institutions of the city shall receive equal and impartial privileges to the full extent consistent with the highest public interests.

" To execute the plans in view it is designed to complete a fund

and secure special donations for buildings, which will enable the Board to have an assured income of from $8,000 to $10,000 per year.

"The Board desire to assure the public that they will spare no effort to realize, in a high degree, the ideal of a Garden which may become a matter of justifiable pride to the citizens of Montreal; but, at the same time, would ask that, since all such important works are necessarily matters of somewhat slow growth, due forbearance be had in the expectation of immediate and striking results."

The circular is signed by the Rev. R. W. Norman, Chairman of the Board; Dr. T. Sterry Hunt; Prof. D. P. Penhallow, Director; Hon. L. Beaubien; Mr. R. Holland, Chairman of the Park Commissioners; and Henry S. Evans, Secretary and Treasurer.

Of the many objects which have claimed generous consideration from the citizens of Montreal, we can recall none which has appealed more forcibly than this, or which has been of a more deserving character. The aim appears to be, primarily, to advance the interests of higher education in this branch of Natural Science; and, secondarily, to develop special research in questions affecting important national interests. On the Continent of Europe, particularly in Germany, no University course is regarded as complete unless it can include the practical instruction to be derived from botanic gardens, while these latter are considered as hardly less important as centres for the promotion of original research and the distribution of information of great practical value and wide application.

The movement is one which has so many substantial arguments in its favor that it cannot fail to meet with the success and support it deserves; and that all the varied interests concerned will be well secured, both with reference to the public and to Science, is well assured in the members who compose the Board of Management. We commend it as worthy of all consideration.

XI. Proceedings of the Natural History Society.

(*Continued from page* 128.)

The Society held their *Annual Field-day* on June 16, 1884, when an excursion took place to Montarville Mountain. The weather was favorable, and a large party left Montreal from Bonaventure Station. From St. Bruno the excursion party drove to their destination.

After lunch, Messrs. Hunt, Penhallow, McConnell and Caulfield acting as judges, the following prizes were assigned:—

Entomology.—1st Prize, Master G. Sumner (26 specimens).
2nd Prize, Master W. Adams (6 specimens).

Miscellaneous Collection.—1st Prize, Miss Jane Lovell.
2nd Prize, Master G. Tiffin.

Named Plants.—Miss Bayliss (35 specimens).

Unnamed Plants.—Miss Martin (36 specimens).

Addresses followed from Messrs. G. L. Marler, Penhallow and Hunt, after which the Society took their way back to St. Bruno.

The *First Meeting* of the Session was held on October 27, 1884, Dr. Hunt taking the chair. The minutes of Council Meetings of September 25 and October 21 were read. On the previous occasion a resolution of condolence was carried to the family of the late G. L. Marler, formerly an active member of this Society.

Messrs. E. L. Trenholm and W. D. Shaw were elected ordinary members of the Society.

The President, Dr. Hunt, then delivered an address upon the meeting of the British Association for the Advancement of Science, held in Montreal during September.

The *Second Meeting* of the Session was held on December 1, 1884.

In the absence of Dr. Hunt, Sir William Dawson occupied the chair.

The following gentlemen were then elected as ordinary members of the Society:—Messrs. J. B. McConnell, C. C. Snowdon, F. W. Radford, H. T. Bovey and A. H. Mason.

Mr. E. Murphy having been called to the chair, Sir Wm.

Dawson addressed the meeting upon the Geology of a portion of the Nile Valley, and described various specimens collected by him during his visit to Egypt.

The *Third Meeting* of the Session was held on February 2, 1885, the President being in the chair.

The minutes of Council, held December 23, were then read, at which the Chairman reported that the Provincial Treasurer would visit the Museum and take into consideration the resumption of the grant to the Society. The meeting agreed to leave the matter in the hands of the President and Sir Wm. Dawson.

The President reported that the Marquis of Lansdowne had consented to become Patron of the Society.

Dr. O. C. Edwards of Winnipeg delivered an address on the habits of the Northwest Gopher, the Turkey Buzzard, the Badger and the White Pelican of Qu'Appelle Valley.

Dr. Baker Edwards then read a paper upon the Sanitary Disposal of Sewage, which was followed by a full and interesting discussion.

The *Fourth Meeting* of the Session was held on Feb. 23, 1885. In the absence of the President, Sir Wm. Dawson was Chairman.

The minutes of the Council meetings of January 20 and February 17 were read to the Society. At the former it was arranged that a Committee should proceed to Quebec and press upon Government the continuance of the grant to the Society.

Messrs. J. Johnston and W. Sutherland were elected as ordinary members and Mr. L. Sutherland as life member of the Society.

Prof. Penhallow then read a paper upon "The Growth Rings of Exogens and their Relation to Age," which was followed by some remarks by Sir Wm. Dawson upon the work of the late Dr. J. G. Jeffreys of England.

The *Fifth Meeting* of the Session was held on March 30, 1885, the President taking the chair, and reporting upon his visit to Quebec.

Mr. Caulfield then read a paper upon "Canadian Diptera."

Prof. Donald then read a paper communicated from Mr.

MacKay upon "Organic Remains in Fresh-water Lakes in Nova Scotia."

Mr. Alex. Mackenzie followed with some Notes on Infusorial Deposits in Nova Scotia and New Brunswick and some of the uses to which the mineral is adapted.

The *Sixth Meeting* of the Session was held on April 27, 1885, Sir William Dawson being in the chair.

The minutes of the Council meeting (April 21) were read, at which a communication was received from the Royal Society of Canada inviting this Society to send a delegate to the Annual Meeting to be held at Ottawa on May 19. A delegate was appointed, the honor being conferred eventually upon Dr. J. B. Edwards.

Mr. C. Gibb renewed his offer to receive the Society at Abbottsford on the occasion of their Annual Field-day.

The portrait of Sir W. E. Logan was then presented to the Society, with an address by Dr. J. Baker Edwards, to which was appended a list of the gentlemen by whose subscriptions the picture had been purchased.

Dr. Blackader was elected an ordinary member of the Society.

Mr. W. Ferrier read to the Society a paper by Mr. G. F. Matthew on "Recent Discoveries in the Cambrian of St. John."

Sir W. Dawson then called the attention of the Society to the work that was being carried on in Egypt by the Egypt Exploration Fund, announcing that Mr. H. R. Ives, a member of the Society, would receive subscriptions from those desiring to become members.

Prof. J. T. Donald then read two papers of "Chemical Notes on Adulteration."

The *Annual Meeting* was held on May 18, 1885, the President taking the chair.

The minutes of the Council meeting of May 12 were read to the Society, in which it was recommended that Dr. Wolfred Nelson and Mr. G. Nelson should be made corresponding members, as a recognition of their kindness in communicating numerous specimens from Panama.

The President then gave a long Address referring to the work

of the Society during the past year, and stating that the second number of the RECORD of the Society should be issued shortly.

Mr. J. S. Shearer, Chairman of Council, then presented his Report for the past year.

The Financial Report was next submitted by the Treasurer, Mr. P. S. Ross, showing receipts to the amount of $1,059.60 and disbursements to the amount of $1,430.75. The discontinuance of the Government Grant was lamented, and it was recommended to convert the revenue from Life Membership into a permanent Endowment Fund. Attention was also drawn to the falling off of revenue from visitors to the Museum. Various means of increasing the revenue were suggested. The necessity of regularity in the publication of the RECORD was emphasized, as well as the advisability of securing a paid editor.

The Curator of the Museum, Mr. William Muir, announced the following donations as having been made to the Museum during the year 1884–85:—

PRESENTED BY

Wm. Muir:
- Turkey Buzzard (*Cathartis aura*).
- White Pelican (*Pelicanus erythrorhynchus*).
- American Badger (*Taxidia americanus*).
- Richardson's sphermophile (*Spermophilus richardsonii.*)
- Grasshoppers (*Udupeylla nigra*).
- Oil Beetle (*Meloe Sp.*).

Capt. Shepherd:
- Night Heron (*Nyctiarda grisea*).
- 2 Red Squirrels (*Sciurus hudsonius*).

H. A. Whitehead:
- Specimen of boulder from East Stanbridge.
- 3 Species of marine mollusca.
- 1 Series of Zoological specimens.
- 1 Specimen of fossil fish.

Dr. Wolfred Nelson:
- Borings from Panama Canal.
- Fossil wood.
- Collection of Indian stone implements.

1 Indian rattle.
1 " whistle.
1 " image.

The several Reports having been adopted, it was carried that they should be printed in the RECORD OF SCIENCE.

Dr. Wolfred Nelson of Panama was then elected a corresponding member of the Society.

Dr. T. S. Hunt exhibited a curious harpoon, the property of Mrs. Guilbault, used by Capt. Brush in 1822.

A ballot having been held, the following members were declared elected as officers for the ensuing year:—

President.—Sir William Dawson.

Vice-Presidents.—Dr. T. Sterry Hunt, Dr. B. J. Harrington, J. H. R. Molson, Edw. Murphy, J. H. Joseph, L. A. H. Latour, Dr. Hingston, Dr. J. Baker Edwards, Rev. R. Campbell.

Corresponding Secretary.—Prof. D. P. Penhallow.

Recording Secretary.—W. T. Costigan.

Treasurer.—P. S. Ross.

Curator of Museum.—Wm. Muir.

Members of Council.—G. Summer, J. T. Donald, J. S. Shearer, Dr. J. B. McConnell, R. W. McLachlan, M. H. Brissette, Alf. H. Mason, J. M. Kirk.

Library Committee.—J. A. U. Beaudry, J. Bemrose, F. B. Caulfield, T. Macfarlane, E. T. Chambers.

A vote of thanks having been moved to the retiring officers, the meeting adjourned.

At a subsequent *Meeting of Council*, held June 1, 1885, Mr. J. S. Shearer was elected Chairman of Council, and the following Committees were appointed:—

Editing Committee.—Messrs. D. P. Penhallow, T. S. Hunt, A. H. Mason and the Recording Secretary.

Lecture Committee.—Messrs. J. B. Harrington, J. Baker Edwards, J. B. McConnell, P. S. Ross and M. H. Brissette.

House Committee.—Messrs. G. Sumner, J. S. Shearer, W. Muir and Major Latour.

Membership Committee.—Messrs. G. Sumner, P. S. Ross, J. S. Shearer, J. M. Kirk, M. H. Brissette, J. Stevenson Brown and the Recording Secretary.

Committee on Exchanges.—The duties of this Committee were left in the hands of the Editing Committee.

The *Annual Field-day* of the Society was held at Abbottsford, on June 4, 1885. The village is situated at the foot of Yamaska Mountain, which gives rich scope for the work of practical students of Natural History. The excursionists were organised into three parties, under the guidance, respectively, of Sir Wm. Dawson, Messrs. Penhallow and McConnell, of Messrs. Caulfield and H. Lyman, and of Mr. Gibb.

Upon the return of the exploring parties the following prizes were awarded by the judges :—

Unnamed Section.—1st Prize, Miss M. Van Horne.
2nd Prize, Miss Oct. Ritchie.

Named Section.—1st Prize, Mr. E. H. P. Blackader (48 specimens).
2nd Prize, Miss F. M. Girdwood (45 specimens).

Entomological.—1st Prize, Mr. R. C. Holden.
2nd Prize, Miss Rose Edwards.

The proceedings terminated with addresses by Sir Wm. Dawson and Dr. T. Sterry Hunt. The thanks of the Society were due to Mr. Charles Gibb for the hospitable way in which he discharged his functions as host and entertainer. This excursion, which will long be remembered as one of the most successful of the Society's outings, was attended by about 120 members and guests.

During the Session the usual course of *Sommerville Lectures* was delivered. The following is the list of the subjects :—

Feb. 12th. " The British Association at Montreal," by Dr. T. Sterry Hunt, F.R.S.

Feb. 19th. " Reminiscences of the late Sir W. E. Logan," by Dr. Robert Bell, F.G.S.

Feb. 26th. " Certain Features of our Climate," by Dr. W. H. Hingston, L.R.C.S.E.

March 5th. " Phenomena of Plant Growth," by Prof. D. P. Penhallow, B. Sc.

March 12th. " On Cholera," by Dr. J. B. McConnell.

March 19th. "Time Observing and Time Keeping," by PROF. C. H. McLEOD, Ma.E.

March 26th. "The Valley of the Nile," by SIR WILLIAM DAWSON, F.R.S.

XII. ANNUAL STATEMENT OF CASH TRANSACTIONS OF THE NATURAL HISTORY SOCIETY OF MONTREAL, MAY 19TH, 1885.

RECEIPTS.

Balance on hand, May 18th, 1884		$638 56
Rents received during the year	440 50	
Entrance Fees to Museum	1 10	
Life Membership, L. Sutherland	50 00	
Subscriptions from Members	543 00	
Donations (Dr. T. Sterry Hunt)	25 00	1,059 60
Total Receipts		$1,698 16

DISBURSEMENTS.

Salaries and Commissions Collecting	$270 25	
Sundry Services of Taxidermist	48 70	
Loss by Extension, June, 1884	67 48	
Repairs to Property, Painters, Carpenters, &c.	36 50	
Carpet for Library, &c.	60 97	
Taxes for two years, including special assessment	289 45	
Insurance, part for three years	91 00	
Printing, Advertising, &c	207 29	
Fuel and light	252 64	
Petty Expenses, &c.	106 47	
	$1,430 75	
Balance carried forward to next year	$ 267 41	$1,698 16

PHILIP S. ROSS,
Treasurer.

Audited and Certified by
JOHN S. SHEARER,
W. T. COSTIGAN.

XIII. List of the Members of the Natural History Society of Montreal.

LIFE MEMBERS.

Burland, J. H.
Chapman, Henry
Claxton, F. J.
Claxton, T. J.
Dawson, Sir J. W.
Drummond, G. A.
Ferrier, Hon. J.
Ferrier, Jas., jun.
Hingston, W. H., M.D.
Hobbs, Wm., jun.
Joseph, J. H.
Kay, W. F.
Latour, Major L. A. H.
Lunn, Wm.
Lyman, Henry
Macfarlane, Thos.
McCulloch, F.
McGibbon, Alex.
Mitchell, James
Molson, John
Molson, J. H. R.
Molson, John Thomas
Molson, John W.
Nivin, Wm.
Redpath, Peter
Robertson, Duncan
Savage, Alfred
Sumner, George
Sutherland, Louis
Watt, D. A. P.
Winn, J. H.
Workman, Thomas

ORDINARY MEMBERS.

Aikman, David
Adams, Robt. C.
Alexander, Charles
Allan, Andrew
Angus, Wm.
Ascher, J. J.
Bagg, R. S. C.
Baker, J. C.
Baker, M. C.
Beaudry, J. A. U.
Beattie, John
Bemrose, J.
Bentley, D.
Bethune, Strachan
Blackader, Dr. A. D.
Bovey, Prof. H. T.
Bowles, G. J.
Brissette, M. H.
Brown, J. Stevenson
Buchanan, W. J.
Campbell, Kenneth
Campbell, Rev. Robt.
Carsley, S.
Cassils, A. M.
Cassils, Chas.
Caulfield, F. B.
Chambers, T. J.
Cheney, Gilman
Costigan, Wm. T.
Craik, Dr. R.
De Lamotte, A. W.
Devine, Thomas
Donald, Prof. J. T.
Drummond, A. T.
Drysdale, Wm.
Duncan, A. E.
Edwards, Dr. J. Baker
Evans, W. N.
Ewan, Alex.
Ewing, A. S.
Ewing, S. H.
Fair, John
Ferrier, W. F.
Fortier, Joseph

Fraser, D. Torrance
Gardner, James
Garth, Charles
Gault, M. H.
Gibb, Charles
Girdwood, Dr. G. P.
Godfrey, Dr. R. T.
Goode, J. B.
Graham, Hugh
Greene, E. K.
Greene, G. A.
Greenshields, E. B.
Greenshields, S.
Harrington, Prof. B. J.
Henshaw, F. W.
Hickson, Jos.
Hodgson, Jonathan
Holden, Albert
Holden, J. C.
Hope, John
Howard, Dr. R. J. B.
Howard, Dr. R. P.
Hutton, James
Ives, H. R.
Jack, Andrew
Jamieson, R. C.
Johnson, James, jun.
Kennedy, W.
Kerry, John
King, R. S.
King, Warden
Kirk, J. M.
Kuetzing, Paul
Lewis, John
Lightbound, George
Linton, Robert
Little, William
Lockerby, A. L.
Lyman, Henry
Martin, P. J.
Mason, Alfred H.
Mathews, F. B.
Mathewson, J. A.
McArthur, Colin
McCallum, Dr.
McConnell, Dr. J. B.
McEachran, Dr.
McGown, A. M.
McKenna, A.
McKenzie, Hector
McLachlan, J. S.
McLachlan, R. W.
McLaren, J. C.
McLennan, Hugh
McPherson, Alex.
Miller, Robert
Mills, Dr. J. W.
Mitchell, Robert
Montgomery, Henry
Morton, G.
Montgomery, Thomas
Mooney, J. H.
Morrice, David
Murphy, Edward
Mussen, Thomas
Norman, Rev. Canon
Ogilvie, John
Ostell, John
Penhallow, Prof. D. P.
Phillips, Henry
Porter, J. A.
Prowse, G. R.
Radford, F. McL.
Richardson, Henry
Riddell, A. F.
Rintoul, W. H.
Robb, Charles
Robert, E. A.
Robert, J. A.
Robertson, Andrew
Robertson, J. A.
Ross, Dr. G.
Ross, P. S.
Scott, Gilbert
Shaw, Henry
Shaw, W. D.
Shearer, James
Shearer, John S.
Shelton, E. E.
Shorey, H.

Silverman, J.
Simpson, W.
Smith, Hon. D. A.
Smithers, C. F.
Snowdon, C. C.
Sutherland, J. B.
Sutherland, Dr. W.
Tees, William, jun.
Thomas, F. W.
Trenholme, E. H.
Trimble, Thomas
Walbank, W. McL.
Wanless, Dr. W.
White, Richard
White, Thomas, M. P.
Wilson, James
Williamson, James
Wood, Dr. C. A.
Wulff, R.
Young, C. J.
Yuille, D.

CORRESPONDING MEMBERS.

Alexander, Sir J. E., 35 *Bedford Place, Russell Sq., London, W. C.*
Allan, E. A. H., *Troy, N.Y.*
Angas, G. F., 48 *Norland Sq., Holland Park, London.*
Ashton, Rev. Michael, *Adelaide, Australia.*
Baird, Prof. S. F., *Washington, D.C.*
Bethune, N. W., *Ottawa, P. O.*
Bois, Rev Ed., *Maskinongé, P.Q.*
Boucherville, G. P. de, *St. Hyacinthe, P.Q.*
Bowen, Dr. Ed., *Brantford, P.Q.*
Brithoner, Rev. W., *Ormstown, P.Q.*
Brodie, M. C., *Beauharnois, P.Q.*
Brown, John, *Hamilton, P. O.*
Brunel, A., *Toronto, P. O.*
Buckland, Prof. W., *Toronto, P. O.*
Bulger, Br.-Major G. E., 156 *Leadenhall St., London, E.C.*
Cameron, Archibald, *Pointe de Chene P.Q.*
Campbell, Col. C. B., *St. Hilaire, P. Q.*
Dessaulles, Cassimer, *St. Hyacinthe, P.Q.*
Fleming, Sanford, *Ottawa, P.O.*
Fortin, P. G., *Laprairie, P.Q.*
Gongrais, J. F. *Quebec, P. Q.*
Guidlack Dr. J., *Ingenio Fermina Bemba, Cuba.*
Hamilton, Dr. J., *Prescott, P.O.*
Hind, Prof. H., *Windsor, N.S.*
Honeyman, Rev. D., *Halifax, N.S.*
Hubbard, Prof. O. P., *Hanover, N.H.*
Laberge, Chas., *St. Johns, P.Q.*
Langevin, J., *Rimouski, P.Q.*
Latour, Dr. C. H., *Boucherville, P.Q.*
Lavalle, Rev. M., *St. Vincent de Paul, P.Q.*
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Lee, Dr. J. C., *London, P.O.*
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XIV. List of Exchanges, etc.

CANADA.

McGill College	Montreal	Que.
Meteorological Office, McGill College	do.	do.
Canada Medical and Surgical Journal	do.	do.
Laval University	Quebec	do.
Literary and Historical Society	do.	do.
Bishop's College	Lennoxville	do.
Canadian Institute	Toronto	Ont.
Knox, College	do.	do.
Meteorological Office	do.	do.
Journal of the Board of Arts	do.	do.
Trinity College	do.	do.
University College	do.	do.
Geological and Natural History Survey	Ottawa	do.
Ottawa Field Naturalists' Club	do.	do.
Royal Society of Canada	do.	do.
Botanical Society	Kingston	do.
Queen's College	do.	do.
Entomological Society of Ontario	London	do.
Hamilton Association, *Alexandrian Arcade*	Hamilton	do.
Natural History Society	St. John	N.B.
Department of Agriculture, Statistics and Health.	Winnipeg	Man.

UNITED STATES.

Smithsonian Institute	Washington,	D.C.
U. S. Geological Survey	do.	do.
U. S. Fish Commission	do.	do.
State Library, State House	Boston	Mass.
Natural History Society	do.	do.
American Academy of Sciences	do.	do.
Harvard College Library	Cambridge	do.
Office of "Science"	do.	do.
Amherst College Library	Amherst	do.
Essex Institute	Salem	do.
Academy of Sciences, 12 *W.* 31 *St.*	New York	N.Y.
Astor Library	do.	do.
N.Y. State Library	Albany	do.
Vassar College	Poughkeepsie	do.
Academy of Natural Sciences	Philadelphia	Pa.
Franklin Institute	do.	do.
American Phil. Society	do.	do.
Silliman's Journal	New Haven,	Conn.

Yale College Library	New Haven,	Conn.
Academy of Sciences	St. Louis	Mo.
University of the South	Nashville	Tenn.
Cincinnati Society of Natural History	Cincinnati	Ohio.
Academy of Sciences	New Orleans	La.

GREAT BRITAIN.

Geological Society	London	Eng.
Royal Society	do.	do.
Entomological Society	do.	do.
Zoological Society	do.	do.
Society of Arts	do.	do.
Chemical Society	do.	do.
Geological Survey of Great Britain	do.	do.
British Museum	do.	do.
Museum of Practical Geology, *Jermyn St.*	do.	do.
Linnean Society, *Burlington House*	do.	do.
Annals and Magazine of Natural History	do.	do.
The Geologist	do.	do.
The Phytologist	do.	do.
The Zoologist	do.	do.
The Ibis	do.	do.
The Technologist	do.	do.
London, Edin. and Dublin Phil. Magazine	do.	do.
Natural History Review	do.	do.
Journal Royal Mic. Society	do.	do.
Chemical News	do.	do.
The Builder	do.	do.
The Engineer	do.	do.
The Gardener's Chronicle	do.	do.
Bodleian Library	Oxford	do.
University Library	Cambridge	do.
Literary and Philosophical Society	Manchester	do.
Natural History Society	Newcastle on Tyne	do.
Botanical Society	Edinburgh	Scot.
Royal Physical Society	do.	do.
Royal Society	do.	do.
Royal Scottish Society of Arts	do.	do.
Edin. Geological Society	do.	do.
Edin. New Phil. Journal	do.	do.
Glasgow University Library	Glasgow	do.
Royal Irish Academy	Dublin	Ire.
Royal Geological Society of Ireland	do.	do.
Royal Dublin Society	do.	do.

CONTINENT OF EUROPE.

Annales des Sciences Naturelles	Paris	France.
Archives de Musée	do.	do.
Académie des Sciences	do.	do.
Société Géologique de France	do.	do.
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Académie des Sciences, Arts, &c.	Dijon	do.
Académie Royale des Sciences	Lyons	do.
Archive fur Naturgeschichte	Berlin	Prussia.
Deutsches Geolog. Gesellschaft	do.	do.
Koniglichen Akademie der Wissenchaften	do.	do
Academy Car. Leop.	Jena	do.
Konigl. Gesellschaft der Wissen	Gottingen	do.
Konigl-Sachs. Gesellsch. der Wissench	Leipsig	do.
Tanhard und Brohn Jahrbucher	Stuttgart	do.
Allgemeine Deutsches Natur. Zeitung	Dresden	Saxony.
Flora	Ratisbon	Bavaria.
Konigl. Bayerichen Akademie der Wiss.	Munich	do.
Kaiserlichen Akademie.	Vienna	Austria.
Imperial Geological Institute	do.	do.
Koninlshipke Akademie de Wet	Amsterdam	Hol'nd.
Société Hollandaise des Sciences	Haarlem	do.
Société Impériale de Naturalistes	Moscow	Russia.
Jardin Impériale Botanique	St. Petersb'rg,	do.
Academie Royale	Brussels	Belgium.
British and American Archæological Society, 17 *Via Prefette*	Rome	Italy.

ELSEWHERE.

Royal Society of New South Wales	Sydney	Australia.

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They also regret the unavoidable irregularity with which previous numbers have appeared. The issues will hereafter be quarterly, the next number appearing in the first week of October. Subscribers, or those exchanging, who do not receive regularly, should at once call the attention of the editors to the fact; and if the first two numbers of this volume have not been received, they will be forwarded upon request.]

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THE CANADIAN NATURALIST.

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CANADIAN RECORD OF SCIENCE.

MONTREAL.

VOLUME I. ... ... NUMBER 4.

I. DISTRIBUTION OF THE RESERVE MATERIAL OF PLANTS IN RELATION TO DISEASE.

BY D. P. PENHALLOW.

By reserve material we understand all those proximate constituents of plants which are either directly or indirectly the product of assimilation, and which are stored up in solid or liquid form to meet some future requirements of growth.

It is essential for us to bear in mind that, such material being the result of an assimilative function which is dependent upon the presence of chlorophyll and the action of sunlight, it can be found, primarily, only in those parts of green plants which grow under the normal influence of light; and, secondarily, also in those parts of green plants which are normally excluded from the light, and to which it has been transferred from the organs where it is formed by secondary processes. It follows from this, that all such material must be absent from colorless parasites, except in so far as they may have taken up the digested material of their hosts and redeposited it in their own tissues, and from all saprophytes. It will also follow that, whatever operates to influence the digestive process in green plants must have a direct bearing upon the amount of reserve material finally deposited, as well as the tissues in which it is stored.

We may consider all reserve material as occurring in two forms, the liquid and the solid. Of the former we have examples in the oils, sugars, inulin and allied compounds, although the two latter may also be obtained in a solid form under certain special conditions of treatment. Of the latter we have familiar examples in the various kinds of starch which, however, is most probably also a liquid at certain times, as when in process of transfer from one organ to another. We should also enumerate, among the solid forms of reserve material, those peculiar forms which protoplasm assumes when passing into the resting state, such as are to be found in the crystalloids, aleurone, etc., or in other words, in the so-called protein compounds of seeds.

It is not the purpose of this paper to discuss all, or even a large portion of these compounds, since the subject is altogether too large to permit of proper treatment within such brief limits, and I shall therefore confine my remarks to that one form of most frequent and conspicious occurrence, starch, since what is true of this in its distribution and relation to pathological conditions, is also true in a very large measure of the other forms of reserve material; and, moreover, it is in the distribution of this in health and disease with which our investigations have been chiefly concerned.

The leaves are the special organs of digestion for the plant, and to them we may consider this function wholly confined; except in cases where there is a green bark, as in all herbaceous plants and the young shoots of woody plants, or where true leaves are absent, and their function is assumed by other parts of the plant, as in the cacti. The products of digestion are in general the same in either case, as, also, must be their final distribution and use, so that what is true of the leaves in their relation to the digestive function must also be true of other green parts. The essential features of the digestive process, as we observe it in leaves, are the decomposition of CO_2 and H_2O with recombination of their constituent elements, giving rise to starch as a solid product to be utilized in nutrition, while free O is liberated into the surrounding air whence the CO_2 was derived. This action may be regarded as continuing during the entire vegetative period, so long as chlorophyll is present and sunlight has free access to the leaves, and, therefore, under otherwise uniform conditions, sub-

ject only to a daily periodicity, due to alternation of day and night. As fast as formed, the starch is disposed of in two ways:—

(1) It is transferred in a soluble form to all the actively growing parts of the plant to meet the immediate requirements of growth. So long, therefore, as vegetation, or the extension of tissues is active, the bulk of all the starch produced is at once disposed of in this way, and there is therefore no excess, but all the tissues show a marked absence of it. This is particularly true during the first one or two months of spring and summer, the solution of the stored starch commencing at a period which antedates the first growth; but as the season advances, maturity of parts replaces rapid extension, and then there is a tendency for the starch to be formed in excess of the immediate demands of growth, and it therefore requires to be disposed of otherwise.

(2) The starch produced in excess of immediate needs is transferred in a soluble form to parts of the plant which have generally lost their power of growth and which contain no chlorophyll, and is there deposited until required by the growth of organs at some future period, generally before the leaves have reached that stage of development which will permit of their assimilating new material. In accordance with this it is generally found that there is comparatively small accumulation of starch in the leaves and other assimilating tissues, while any excessive development there becomes at once indicative of disordered function.

It is impracticable to place a quantitative limitation upon the amount of starch which may normally be present in tissues, and apply that law to all periods of vegetation; the limit can only be established as a matter of experience, since in early summer, when growth is most active—the requirements of tissue-formation keeping pace with the power to supply—the tissues all contain a minimum of starch; but toward the end of summer, as growth ceases, there is a tendency to greater accumulation in all the tissues. At the end of the season, as the leaves ripen previous to their annual fall, whatever starch they contain is either withdrawn to the permanent structure of the plant, or it enters into fatty degeneration. Such changes are normal. If, on the other hand, such accumulations or fatty degenerations occur at other than their normal period, or if in excess at this time, as fatty degeneration during the month

of June, or excessive accumulation of starch in the bark during active growth, they at once become certain and most important indications of disease.

As in the early period of vegetation, the nutritive and assimilative functions are nearly balanced, there is no surplus material to be deposited. As the season advances, growth diminishes and the products of assimilation then become in excess, in which case they are stored up—most generally in tissues which have long since lost their power of growth—and are therefore designated as permanent, though sometimes in tissues still active, but specially modified as reservoirs of reserve material. These reservoirs represent different tissues and organs in different plants. In the potato, it is the tuber itself; in the lily, it is the modified leaves forming the scale of the bulb; in the carrot, it is the root; and in the century plant, it is each leaf, which becomes specially modified for that purpose. Our particular purpose, however, will be best illustrated by confining our attention to trees and other plants in which the woody structure is largely in excess. Here the distribution of the starch for storage is determined first of all to the pith, next to the medullary rays and woody cells, and last of all to the bark, thus being correlated to the activity of the tissues themselves. In trees, the deposition of starch may be regarded as commencing somewhat late in the season, and increasing, as growth diminishes, to the time when the function of the leaves ceases.

No law can as yet be stated concerning the amount of starch which should normally be deposited in the various tissues, but as the result of examinations into the histological condition of several thousand specimens taken from a great variety of trees and shrubs, examined at all seasons of the year, the following conclusions appear to be justified :—

1. While, in general, plants store reserve material at the close of the growing season, this law cannot find specific application in all cases and for all tissues.

2. Woody plants generally contain reserve material in their permanent structure during the period of active growth, but the presence of starch in the cortical tissues during this time is variable in different species, and depends upon the special physiological functions of the subject.

3. The reserve starch is least during active growth and greatest just after the fall of the leaves.

4. The amount of stored material is most variable in the bark, and least variable in the wood and pith.

5. Reserve material appears most abundantly in the oldest tissues and those which are most strongly lignified, least abundantly in the tissues where the vitality is greatest.

6. The storage of the carbohydrate is first in the old and lignified cells, and last in the most active structure.

7. The solution of the stored starch is first in the active parenchyma cells, and last in the permanent tissues.

8. There is a gradual solution of the stored starch during the period of rest.

9. Leaves normally contain an abundance of starch during the period of their greatest activity, but as they ripen the starch is replaced by oil.

In 1871, Nobbe and Schroeder demonstrated the influence which may be exerted upon this distribution by an abnormal food supply. Their experiments with buckwheat, to determine the specific value of chlorine and potash, were found to have an important bearing upon the products of assimilation. The potash, as is now so well known to be the case, was found to be essential in the first instance to the formation of the reserve material, while the chlorine was observed to bear a most important relation to its final distribution. Withholding the chlorine, the starch accumulated in the tissues where formed, so that the bark and leaves became abnormally charged with it, particularly in the young growth. At the same time there was marked atrophy, together with high discoloration of all the growing parts, showing a failure of proper nutrition and, therefore, of distribution of the digested material. Restoration of chlorine to the food-supply gradually effected distribution of the starch and restoration of the normal growth. This then shows what may be produced by artificial treatment, and clearly demonstrates the dependence of the physiological activity upon the presence of special elements and compounds. It also leads us to infer that similar abnormal conditions may develop whenever the plant is deprived of these special elements of food under conditions of ordinary growth.

Acting upon these suggestions, Dr. Goessmann and I have, for

several years past, been endeavoring to determine the possible existence of similar conditions in plants growing under ordinary influences, and their relation to specific diseases. The results of our examinations show most conclusively, that in certain diseases, e.g., peach yellows, we have to deal with essentially the same histological characteristics as were artificially produced by Nobbe and Schroeder in the case of buckwheat, and not only that, but that the disease can be produced and cured at will.

In order to understand this, it will be necessary to deal with the experiments in both their chemical and botanical aspects.

In dealing with the chemical changes involved, it was deemed essential, first of all, to determine what mineral constituents normally enter into the composition of both fruit and wood in its healthy condition, and to compare these quantitatively with the constituents found in the ash of corresponding structures in a state of disease. The analyses obtained were as follows :—

Fruit of Crawford's Early.	Healthy.	Diseased.
Ferric oxide	0·58	0.46
Calcium oxide	2.64	4·68
Magnesium oxide	6·29	5·49
Phospheric acid	16·02	18·07
Potassium oxide	74·46	71·30
	100·00	100·00

These results at once made it clear that in the diseased, as compared with the healthy, the ash contains more phospheric acid and lime, and less potash. Previous examinations and experiments with strawberries and grapes had already demonstrated the superior importance of potash in improving the qualities of these fruits, and the inferior value of lime, and it seemed possible that similar results might be obtained here in the case of the peach. Analyses were, therefore, made of the diseased wood, and acting upon the theory that potash and chlorine were probably the two elements most needed, a number of diseased trees were treated with muriate of potash. After the lapse of a few years, they lost all appearance of disease, and were restored to such a condition of health that, up to the present time, they have been most profitable in their production of fruit. An analysis of the

wood was now made for comparison with that of the diseased wood. The results follow:—

Wood of Crawford's Early.	Restored.	Diseased.
Ferric oxide	0·52	1·45
Calcium oxide	54·52	64·23
Magnesium oxide	7·58	10·28
Phospheric acid	11·37	8·37
Potassium oxide	26·01	15·67
	100.00	100.00

This comparison shows the same deficiency of potash and excess of lime in the diseased, as previously noted, and what is of great significance, that the excess of lime in the one and deficiency of potash in the other, or the decrease of lime in the healthy and the corresponding increase of potash, stand about in the relation of equivalent value. Other analyses fully confirmed these results, and the final conclusions reached were, that, since in the diseased condition there was always an excess of lime and deficiency of potash, and as the relations of these could be changed by conditions of treatment causing increase of potash and decrease of lime, together with the promotion of a healthy organism, that, so far as chemical data could determine, the disease was caused by, or at least associated with, imperfect nutrition.

At this stage, it became most important to determine the relation of the reserve material to these various changes, and in order to arrive at a clear understanding of this, we must discuss the various external and internal indications of disease.

Among the external features which characterize the disease in peaches, we must take into consideration the formation of the fruit, the formation of the wood, the color of the bark and the color and size of the foliage.

The color of the bark is one of the first symptoms to develop. Instead of retaining the natural, reddish hue which all healthy trees possess until well advanced in years, the bark turns dark and has the external appearance of drying up. As the tree becomes more involved in disease, the foliage begins to show indications of the fact. The normal size of the leaf is from 15 to 18 cm. in length. The color is a rich leaf green. The outline is somewhat wavy, but the surface is uniform and not depressed by irregular curlings. As the disease advances, however, the leaves

decrease in size, the chlorophyll undergoes modifications or is imperfectly formed, an abnormal red, yellow and green color is developed, and all these conditions continue to increase until the extremes are reached.

The last external characteristic is to be found in the abnormal development of the new wood. The branches of the new growth become more strongly atrophied as the disease advances, until they finally become of a very wiry character and develop upon the trunk and branches in clusters.

The internal features are as strongly marked as the external, and may generally be determined in very early stages of the disease. The first indication is to be found in the very dense accumulation of starch, not only in the pith and medullary rays, but particularly in the bark, from which it should normally be absent to a very large degree. This excessive accumulation of digested material in unusual parts, is at once indicative of an imperfect power of distribution to the growing parts and inability of the plant to convert it into tissues, so that the atrophy of structure appears in the first instance, not to be caused by want of material, but by the absence of certain chemical compounds by which the necessary chemical changes of direct nutrition may be accomplished.

This accumulation of starch increases as the disease progresses, while, at the same time, very important modifications in the tissues themselves, are developed, particularly in the bark. There the cells of the middle bark, or mesophlœum, become relatively thick-walled; the intercellular spaces decrease in size and number and thereby retard the proper respiratory function; the disposition of the cells becomes somewhat regular, the tendency being to the development of layers forming well-defined concentric rings, while the form also tends strongly to an elongated ellipse with its minor axis running in a radial direction.

Contrasting this with the normal, we find in the latter that both the internal and external features are markedly different. The leaves are a deep green, and of large size, as already shown. The young shoots, likewise, are of a lively green color, and two or three times the diameter and several times the length of the diseased. Internally, the starch, in comparatively small quantity, is confined almost wholly to the pith rays and wood, the bark con-

taining but little. The structure of the bark shows that the intercellular spaces are large and frequent, the cells arranged without order, irregular in form and size, and with relatively thin walls.

We are now to inquire what relation, if any, these histological conditions bear to the chemical constitution of the ash already referred to, and particularly to the chemical results derived from an examination of the tree restored to health by treatment.

1st. In the normal plant, the full exercise of its functions of growth and a normal histological condition occur, when potash and chlorine are relatively in excess and lime is relatively wanting.

2nd. In the diseased plant, the imperfect nutrition and distribution of the reserve products, as also modifications of the cellular structure, are associated with deficiency of potash and chlorine and excess of lime.

3rd. We are to inquire as to the relation in which the restored tree stands to all of these.

The chemical analyses already referred to show that, when the restoration from abnormal to normal functional activity occurs, the chemical constituents change their relations to those observed in the normally healthy, i. e., the potash becomes in relative excess. At the same time, the histological conditions show a corresponding change, and as the new growth develops, the structure and also the cell-contents assume precisely the conditions of development and distribution found in the naturally healthy tree.

These results may be regarded as fairly conclusive so far as this particular disease is concerned, but we can as yet hardly apply generally the laws here determined. However, the fact here developed with reference to the distribution of the reserve material will not apply with equal force to other trees or plants, since there are very important variations in this respect, dependent upon the physiological characteristics of particular species, or at least of particular families of plants. Nor will the same chemical elements, or the same chemical compound, be equally efficient in all cases in determining a similar result, since here, also, the effect is determined by specific physiological peculiarities. This is well illustrated in the peach and the pear: both belong to the same family *Rosaceæ*, yet the peach belongs to the group *Amygdaleæ*, while the pear belongs to the group *Pomeæ*, indicating at once specific physiological differences. And while

potassium chloride will exert a most beneficial effect in the peach. it is comparatively worthless when applied to the pear, for which the potassium sulphate appears to be the most efficient combination.

II. Notes on Movement of Water in "Robinia Pseudacacia."*

By Miss G. E. Cooley.

The influence of transpiration in determining the upward movement of water in plants is fully recognized; but, apart from that force, another appears to act in conducting water to the leaves, the proper physical causes of which are not well understood as yet.

The root-hairs and other active cells of the root derive moisture from the soil through osmosis, and are thus brought into a state of positive tension, while the contained fluid is in a state of negative tension. Sachs† points out that the necessary release from this tension must be into adjoining cells as offering the least resistance. These are in turn made tense, and the action continues from the lower to the higher cells, thus conducting the water from the root to the stem. Root-pressure is the expression of this tension of tissues by which water ascends in plants, through osmosis acting as a primary influence. This force of root-pressure is very variable in plants of different species, but in general it is found in all plants with a well-developed root-system. That it is a strong and well-marked force can be readily shown, if the proper conditions are observed, by manometric measurements, when the amount is found to be considerable; as demonstrated by Clark ‡ in the case of *Betula lenta*, amounting to the equivalent of 68 inches of mercury or 77 feet of water, and of *Vitis æstivalis*, 78 inches of mercury or 88.4 feet of water.

Such a power, as this can be shown to be in actively-absorbing roots, must be an important factor in supplying the deficiency of water lost by transpiration; or, as often happens in some species

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* Observations made in the laboratory of Prof. Penhallow, Montreal, during the summer of 1885.

† Sachs' Text Book, p. 687.

‡ Phenomena of Plant Life, 1874.

of Aroideæ, where transpiration is comparatively weak, it may even exceed the evaporation from the leaves, and cause exudation in drops from their tips. This is by no means the rule, however; on the contrary, the loss caused by transpiration usually tends to produce a vacuum in the stems and lower tissues, which is only slowly compensated for by root-pressure. This is shown by the well-known fact that if an actively transpiring plant be cut off a few centimetres above the ground and water applied to its cut surface, it is rapidly sucked in, and it is only after the lapse of some time that root-pressure predominates, but then water is forced up the stem and out at the cut surface in large amounts and even against pressure. This action will continue until the roots die, with a force, varying but generally increasing to the maximum, and then gradually decreasing until the force is exhausted.

It was to determine the movement of water, chiefly as exhibited in root-pressure under the influence of atmospheric conditions, that the following experiments were entered upon.

A mercurial manometer of the ordinary form, nine decimeters long and with graduations reading to mms., was set up in the open air beside the plant, and connection with the stump was made by a rubber tube bound with book-linen to prevent expansion under pressure. All the fastenings were made air-tight, and all air was removed from the water column connecting the mercurial column with the stump, and the tube was then pressed down over the stem, which was cut off four cm. from the ground, *i.e.*, below the lowest leaf. The plants selected were vigorous shoots of *Robinia pseudacacia* of this year's growth. All were from 6 to 10 decm. in height 0.5 and 0.7 cm. in diameter, and were situated from 15 to 20 ft. from the parent trees. An examination showed an intimate connection between the suckers and these trees. The running roots from the tree give rise to buds which develop into strong shoots having at first no root system of their own, the old root continuing its course and becoming the primary root of the new plant before the connection with the parent tree is severed. All the roots showed a swelling at the juncture with the sucker, and some of them exhibited signs of decay a few inches back of the swelling, but in most, the connection with the main root of the tree was perfect, as the results of the experiment will show.

Robinia Pseudacacia No. I.

Date.	Hour.	— Reading.	+ Reading.	Differences.	Lbs. pressure per sq. in.	Temp. F.	Rel. Hum.	Mean Daily Temp.	Mean Daily Rel. Hum.	
July 18th...	10.00a.m.	1.65	2.25	+ .600	+ 1.16	64.4°	50%			Temp. and R.H. taken at 11a.m. and 3 p.m.
" "	10.30	2.08	1.83	— .145	— 0.28					
" "	10.45	2.12+	1.68	— .440	— 0.85					
" "	11.30	2.12+	1.40	— .720	— 1.39					
" "	12.00	2.12+	1.32	— .800	— 1.55					
" "	12.05p.m	2.12+	1.24	— .880	— 1.70					
" "	12.15	2.12+	1.24	— .880	— 1.70					
" "	4.10	1.85	1.91	+ .065	+ 0.12	74.1°	48.0	63.42	58.3	
" 20th...	10.00 a.m.	1.97	1.93	— .040	— 0.07	73.9°	55.0	71.22	65.7	[The scale is in decimeters.]

Robinia Pseudacacia No. II.

Date.	Hour.	— Reading.	+ Reading.	Differences.	Lbs. per sq. in. pressure.	Temp. F.	Rel. Hum.	Mean Daily Temp.	Mean Daily Rel. Hum.	Remarks.
July 20th....	12.00	2.950	2.950	0.00	0.00	73.9°	55%			Temp. and Humidity taken at 11 a.m. and 3 and 7 p.m.
" "	12.30p.m.	2.300	3.600	+01.3	2.51					
" "	12.35	2.950	2.950	0.00	0.00					
" "	3.30	3.030	2.870	—0.16	—0.177	77.1	49.0			
" "	3.45	2.985	2.915	—0.07	—0.136					
" "	4.00	2.985	2.915	—0.07	—0.136					
" "	4.15	2.980	2.920	—0.06	—0.116					
" "	4.30	2.975	2.925	—0.05	—0.090					
" "	5.15	2.960	2.950	—0.01	—0.019					
" "	7.50	2.940	2.960	+0.02	+0.038	72.9	70.0	71.22°	65.7%	H_2O in the tube.
" 21st....	11.00a.m.	3.070	2.770	—0.30	—0.570	73.0	88.0			Raining.
" "	3.00p.m.	3.350	2.500	—0.85	—1.640	77.0	77.0			Clear, damp, warm.
" "	4.00	3.000	2.900	—0.10	—0.190					Light clouds.
" "	5.00	2.960	2.930	—0.03	—0.500					Clear.
" "	5.45	2.945	2.955	+0.01	+0.019					
" "	7.45	2.935	2.965	+0.02	+0.038	72.5	93.0	70.07	88.20	H_2O replaced.
" 22nd ..	10.00a.m.	2.870	3.030	+0.16	+0.177					
" "	10.30	2.850	3.060	+0.21	+0.406					[The scale is in decimeters.]
" "	11.00	2.840	3.080	+0.28	+0.540	75.3	58.0	71.62	61.20	

An examination of the tables will show that the first action of the stump wasthat of suction,—the mercury, which had risen at the moment the tube was drawn over the stem, having quickly fallen. This we were led to expect from the rapid transpiration of the shoot, and the consequent exhaustion of moisture from the stem before it was cut. This suction continued and reached its maximum at the hottest part of the day, or when the parent tree was most actively transpiring, evidently pulling upon the water in the manometer through the root-stock of the sucker. After the maximum was reached, the action decreased until sunset, when a slight pressure was observed; and, if the records had been made during the night, it is probable that a still higher pressure would have been registered. In the second table, it is noticeable that during the rain of the morning, there was recorded only one third the amount of negative pressure that appeared at 3 p.m., when the air was warm and the sun shining. At the close of the experiment, the water in the rubber tube was replaced by air from the stem, and all fluctuations after that time were evidently caused, at least in part, by variations in the temperature acting upon the column of air above the stump.

The experiment is interesting as showing how vigorously a transpiring tree draws upon its roots even to the distance of 30 ft., and upon its young shoots, in opposition, to the more feeble draught of the sucker, as the moisture evaporates from its leaves. These stems wilt very quickly when cut down, showing, as did the manometric action, that the stems were almost empty.

From the fact that air in some cases finally replaced the water, it appears that, in spite of all precautions to the contrary, the apparatus, while air-tight for slight pressures, did not prove so for those of considerable increase; so that, the maximum of negative pressure permitted by the apparatus being reached, the mercury then fell back to a height which was within the limits of the instrument.

So far as we are enabled to determine from these results, it would thus appear :—

1st. That the influence of transpiration is felt in very remote parts of the plant.

2nd. That, in this case at least, root-pressure has but little value in supplying the wants created by transpiration.

It will be the object of further experiment to see how the roots

are able to draw water from the sucker, which the experiment shows to be done, and, as a contrary function, to provide it with sufficient nourishment from the parent tree to make a healthy growth.

It is a fact worthy of note, that this plant takes unusual care to provide for its propagation. Most of the roots examined showed evidence of buds already formed for another year, and wherever the suckers had been cut down in previous seasons, two or more buds had taken their place. In one instance where worms were injuring the root, the expiring tissues redoubled their exertions, and eight shoots and twelve buds were produced in 4 inches of root. Such a state of affairs renders it exceedingly difficult to eradicate the undergrowth of the Robinia.

III. Ancient Insects and Scorpions.

Fossil scorpions have been known for some time as far down in the geological series as the Carboniferous, in which formation about twenty-five species of scorpions and spiders have been discovered, but until last year no discovery of this kind had been announced in any older rocks. In November last, Dr. Lindström of Stockholm, announced the discovery of a well-preserved specimen of a true scorpion, which he named *Palæophoneus nuncius*, in the Upper Silurian of Sweden; and in December of the same year, a similar discovery in Scotland was announced by Dr. Hunter. In July of this year, Prof. Whitfield of New York described and figured a third species in the Lower Helderberg series of the State of New York. Thus this form of life has been at one bound, and in three different localities, carried back from the Carboniferous to the Silurian, a remarkable instance of the nearly simultaneous discovery of new facts, in different places and by different observers. It is also of interest that the crustaceans of the genus *Eurypterus*, which have been called aquatic scorpions, appear in the same formations in which the scorpions have now been found, so that it would appear that the aquatic and aërial animals of this type of structure originated together, or were at least contemporaneous in the Silurian period. The Eurypterids, however, early became extinct, while the scorpions survive.

The insects had previously been traced back to the Devonian or Erian period, and the scorpions would now have antedated them, but for another discovery made in Spain by M. Donville, and communicated to the Academy of Sciences by M. Charles Brongniart in December, 1884. This is a wing of an insect in the sandstone of the Middle Silurian, probably equivalent to our Niagara series in Canada. This wing is shown by its venation to belong to the Blattidæ or cockroaches, a group already well-known in the Carboniferous, where they seem to have thriven on the abundant vegetable matter of that period. It differs, however, in some of the details of venation from any living or fossil species previously known. Brongniart proposes for it the name *Protoblattina donvillei*, and as the beds containing this insect are probably a little older than any of those containing the scorpions above referred to, this discovery makes the cockroaches, still so numerous and voracious a family of insects, the oldest known air-breathing animals. It is to be observed, also, that the group which thus has priority belongs to the insects which have an imperfect metamorphosis, and to the order *Orthoptera*. In connection with this, it seems that all the insects hitherto known in the Carboniferous period belong (with the exception of species uncertainly referred to the moths and the beetles) to the three closely allied groups of *Orthoptera*, *Neuroptera*, and *Hemiptera*, all having incomplete metamorphosis, so that in any case this group was the dominant one of insects in the Palæozoic period. With the exception of a few lycopodiaceous plants we know nothing as yet of Silurian land vegetation, but the Spanish *Protoblattina* suggests to us the existence of Silurian forests producing some kind of succulent and nutritious vegetable food, while it also furnishes an explanation of the possible means of sustenance of the carnivorous scorpions.

J. W. D.

IV. Dance of the Prairie Chicken.

By Chas. N. Bell, Winnipeg.

At sunset on the evening of May 10th, 1873, near Saddle Lake (*Saw-gi-ah-gun Aspapowin*), which is twelve miles north of Upper or North Saskatchewan River, and ninety miles north-west of Fort Pitt, or in latitude 54° N. by longitude 111.40° W., I first had the good fortune to witness that most amusing dance indulged in during the spring season by the Prairie Chickens, when courting preparatory to mating for the summer. The Prairie Chicken, or Sharp-tailed Grouse (*Pedioccetes phasianellus*)*, the Pheasant of the Hudson's Bay Company residents, is called in the Cree, as well as in the Saulteau or Chippeway language, *akiskow* or *awkiscow*,—the Crees also using an alternative name for it, *pehayo*.

I had been without any food worth speaking of for some forty-eight hours, and was roaming about amongst the ponds and hills in search of game, feeling fairly used up with fatigue and hunger, when I heard a most peculiar sound, apparently coming from a great distance and resembling somewhat the murmur of many voices. At once taking cover in the willow brush, which grew in long patches in a depression between two rolls of the prairie, I quietly pushed forward in the direction from which the sound came. Every few yards I stopped to listen, thoroughly puzzled as to the cause of the extraordinary bursts of noise succeeded by perfect silence. Could it be Indians? A few Crees had passed my log wintering hut during the past week, and some of these might here be discussing a plan to rob the *moneass* ("stranger," or literally, "greenhorn") who was living alone forty miles from the nearest settlement.

I determined to find out what it all meant, so keeping my double-barrelled muzzle-loader in readiness, I dropped down on all-fours and quietly crept forward. For a few minutes all was very still and quiet, when suddenly, from a spot but a few yards a head, where I could see that there was an open space,

* The Prairie Chicken is a term applied to two different species of grouse—the Pinnated grouse or the *Tetrao cupido* of naturalists, and the Pintail or Sharp-tailed grouse of the text. In 1870, the Pintail only was to be found in the Northwest; but the Pinnated grouse advances with civilisation, replacing the Pintail.

there came a perfect babel of sounds. Creeping slowly forward I noiselessly pushed the willow boughs aside, when my glance fell on a covey of some fifty prairie chickens covering the top of a small dome-shaped mound. They were running about and per orming all sorts of strange movements. Every now and then, one would jump into the air for a foot or two, with all its feathers ruffled, the air-sacs on its neck inflated, and pouncing down, strike at another, who either stood his ground to receive the attack, or turned tail and fled, to be pursued by his antagonist. Here and there a hen was rushing through the throng, followed by two or three male birds, who stopped at intervals to combat with great fierceness.

The scene was indescribably funny. At times they gathered in a cluster near the centre of the hillock, struggling, fighting and making each others' feathers fly, all the time emitting a series of peculiar sounds, cooings and sharp angry cackles mingled with drumming. For a time they were motionless and quiet, when a single individual pranced out from the others and began strutting about, with his head bobbing up and down, his tail opening and shutting rapidly with a rustling noise. Suddenly he broke into a jumping, stamping, sort of jig-dance, beating a quick time on the ground with his feet, moving them so rapidly that a sound was produced like that resulting from the strumming on one string of a banjo, and joining to this a flapping of his wings and a rapid whirr of his tail. He then capered about, jostling against the others, for by this time the whole assemblage was imitating him, and it soon became a question of the "survival of the fittest." It was for all the world like an Irish cutting-out jig, or the celebrated Red River jig, only that, instead of two or three dancers taking part, the whole party took the floor. Suddenly, as if tired out, they separated and scattered over the mound, the hens apparently making for the brush and the cocks following, until two of the latter came together, when a pitched battle at once took place.

By the time they had once more gathered in the centre of the ball-room floor the pangs of hunger had again attacked me, so I gave up enjoying the sight, quickly levelled my gun and fired into the midst of the crowd, knocking over for one the floor-manager as he once more began to lead the dance. Consternation seemed to strike them motionless, and it was not until I rose upright that they began to scatter and fly off with an abrupt cackle, obtaining

sufficient headway by a dozen flaps of the wings to sail thirty or forty yards at a stretch. As they rose in the air, I knocked down two more, thus securing an excellent meal. During the next day I laid out on the mound, which was beaten smooth by the trampling and stamping of many little feet, a set of bent rods, inserting the ends well into the earth, and suspending from the arches thus formed running nooses of buffalo sinew in the same manner as is followed in snaring rabbits. For several evenings and mornings these snares supplied me with from one to three birds; but they finally either mated or grew wary, for they refrained from indulging in their dance in that locality.

The fierceness with which they fought may be judged from the fact that in several cases when birds were snared, a lot of feathers were plucked from them, and the skin on the top of the heads was completely pecked off. The poor unfortunate bird, held fast by the sinew loop, was soon killed by his blood-thirsty companions.

V. Some Prehistoric and Ancient Linear Measures.

By R. P. Greg.

I have for a considerable length of time been engaged on an investigation concerning the units of measure among certain ancient nations; and though there is not space, within the limits of a mere communication * like the present, to enter upon the whole ground gone over, which would moreover entail a considerable number of figures and illustrations, I will, as briefly as possible, recapitulate some of the leading results, about which, I think there is little reasonable ground for doubt, and which may lead to interesting results.

1. *Peru.*—From the measurements afforded, mostly by a number of small objects, it would appear that the ancient Peruvians of the time of the Incas employed the same inch and foot as did the Aztecs and Toltecs, and Central Americans: viz., a foot equal to $11\frac{3}{4}$ inches English, or say a fraction more than the old Roman or Solon's foot. This foot $=.298$ of a metre, and was

* Communicated as correspondence to *The Academy*, July 4th and 25th 1885.

divided into twelve equal parts. As with the Mexican foot, in reducing English foot measurements as given in books of travel and architecture, it is only necessary to add 2 per cent.; 100 English feet equal 102 Mexican and Peruvian.

2. *Mexico and Central America.*—From measurements of many small objects again, as well as from various other confirmatory methods it may be safely stated that the unit of measure employed by the ancient Mexicans was a foot of 12 inches, equal to 11¾ inches English. Since arriving at this conclusion, I have received a little pamphlet on the subject of ancient "American Linear Measures," by Dr. Daniel Brinton, of Philadelphia, in which he shows that the old Mexican *octacatl* was, "as deduced from the yard, or *Vara de Burgos*, equal to 9·84 English feet, which would make the *octacatl* a 10-foot measure, and a multiple of the length of a foot; as is proved by an analysis of the word." That result Dr. Brinton adds, "is as interesting as it is new, as it demonstrates that the metrical unit of ancient Mexico was the same as that of ancient Rome, *i.e.*, the length of the foot print." Mr. H. Seebohm says the Roman foot, or foot of Solon, was = ·296 metre, consequently Dr. Brinton's calculation is almost identical with my own, viz., ·298; which, moreover, is fairly deducible from the 4 palm foot of the Egyptian (royal) cubit of ·525 metre. Mr. Petrie's reductions of the Mexican foot of ·260, as well as of other old North American ones of ·170, ·315, and ·325, seem to be incorrect. My correction of 2 per cent. added in fact to Dr. Brinton's 9·84 ten-foot measure, would make the old *octacatl* almost precisely 10 old Mexican feet. The same correction also added to the 11-foot 9-inch diameter of the celebrated Mexican "Calendar" stone would show that a precise diameter of 12 feet was intended. Moreover, on that very stone, round a portion of the outside or rim, are 18 square divisions or cartouches, representative of the months of the Mexican year, each exactly a Mexican foot square. Curiously, the equally celebrated so-called "sacrificial" stone, probably once also a calendar, stated to be a few inches over 9 feet English in diameter, would, for 9 feet 5 inches, give 360 to 365 Mexican inches for circumference, probably intended as 1 inch for each day of the year. In Lady Brassey's fine collection of gold ornaments from graves in Antioquia, Northern South America, figured and described by Mr.

Bryce Wright, there is a gold band 23⅜ English inches long, evidently intended or cut off for 2 Mexican feet (= 23⅞ inches). A number of articles in the same collection measure exactly 1, 1½, 2, 2½, and 3 inches Mexican. A flat jade object, like a paper knife, with two holes for suspension, probably, to a workman's belt, measures precisely 6 inches Mexican, and may have been a half-foot measure.

3. *Mound-Builders of North America.*—Prof. Daniel Wilson, of Toronto, in the second edition of his "Prehistoric Man," p. 221, describes a curious stone tablet or implement, found in a grave mound at Cincinnati in 1841 (it is also figured or described in Squier and Davis, and other works). His figure is given ¼ size, but is not quite accurate, for I have since received a rubbing from a cast of the original in the Blackmore Museum at Salisbury, and do not find that Dr. Wilson's figure is correct, nor the description of some of the details. This tablet has never been thoroughly explained. Some have thought it to be a calendar, others a measure, and some a mere stamp for printing textile materials. The greater part of its upper surface is covered with a scroll-like pattern, but at each end are scales, containing each two sets of divisions, evidently intended for some special purpose. Describing it best from the tracing or rubbing sent me by Dr. Blackmore, of Salisbury, it has at one end a series of 23 + 1 small nearly equal divisions, in connection with 7 larger ones, say 3⅛ small to each larger one; and at the opposite end a series of 6 larger divisions, in connection with 20 + 4 smaller ones, somewhat similarly disposed. The length of each scale is about 2¼ inches English. The longer sides of the tablet are curved to a 12 mound inch radius. The length and breadth of the stone tablet itself is very nearly 5 inches English by 2½ at the narrower middle part; consequently, almost exactly the same by Mexican measure. It struck me that this tablet looked very much as having something to do with a possible half-foot measure; and I further observed at each corner, not before noticed by any archæologist, two straight lines, evidently not forming part of the general ornamental scroll pattern, which I guessed might possibly have been intended to represent the mound builders' standard inch, or finger breadth. On scaling this as a foot of 12 inches I found I had obtained means of a measure for many North American

things described in books and museums, which has in other ways been curiously confirmed. It is even a unit of measure for the stone tablet itself. This mound inch is shorter than the English inch, in the proportion of 10 to 12; and it is evident that the mound foot was one divided into 12 inches, for the tablet itself is exactly 6 of its own standard inches in length, *i.e.*, doubtless half a foot, and exactly 3 inches in width at the middle or narrower part and 3½ across the wider ends. In Dr. C. Abbott's "Primitive Industry of America," Fig. 356, p. 375, there is figured and described what is called a "Slickstone"; and noticing a number of small notches (about 8 or 10 to an inch) on it, I tried the length, and found it to be 6¼ inches long, but with a large corrective notch right across near one end, at precisely the 6-inch length. With often equal success I applied this, my mound-builder's foot-rule, to many objects described by Squier and Davis, and in Dr. Abbott's book more particularly, which I have no space at present to go farther into, but refer to Figs. 142, 192, 195, 362—particularly to Fig. 365, p. 388, a fish totem measure, of exactly 1 mound foot in length and nearly 3 inches in breadth. Also see Fig. 43, p. 71, representing a flattish stone of about 7 × 3½ inches, whereon are scratched a series of 15 small notches, exactly = 1¼ mound inch, showing a decimal division, with four other larger notches, showing some other inch. It would appear, then, that the length of the mound-builder's foot was precisely 10 inches English = ·254 metre, and that there would be 7 mound inches to 6 Mexican inches. Entirely independently of my own results I have since found in Dr. Brinton's pamphlet, p. 11, "Colonel C. Whittesley of Cleveland, in 1883, analysed 87 measurements of these mound earth-works by the method of even division, and concluded that 30 inches (English) was about the length or was one of the multiples of their metrical standard,"—thus indirectly confirming my own discovery that the mound foot of 12 inches was precisely =10 English inches, at least so far that 30 is a multiple of 10. From about 200 mound measurements, I have found that 25 English, or 30 mound, feet are a probable standard unit for large measurements. Squier and Davis mention prehistoric North American garden plots 12½ English feet wide, which would =15 or 12½ mound feet.

Incidentally, I have also reason for supposing that the mound-

builders' acre, or larger unit of superficial measure, was equal to $1\frac{8}{9}$ to $1\frac{7}{16}$ English acre with square-side of 300 mound feet (30×10), equal to 250 English feet, and that the favourite square and circle areas of 20, 27, and 40 (or 41) English acres meant 15, 20 and 30 mound acres respectively.

If the mound-builder's foot of 12 inches (finger breadths?) was equal to 10 English inches, it would follow that most mound measures expressed in English feet (as in Squier and Davis's "Monuments of the Mississippi Valley") would give for 250 feet, say 300; for 750, 900, for 835, 1,000; for 920, 1,100; for 1,000, 1,200; for 1,080, 1,300; though it is not impossible that Mexican feet for large measures may have been sometimes also used, in proportion of about 12 to 13; when 930 feet would be = 1,000 feet, or side of a favorite square area of 15 mound acres or 20 English acres.

4. *Prehistoric Measures of North America.*—Besides many objects found in the mounds of Ohio and Tennessee evidently giving mound-builders' measure, as well as in New Jersey, Massachusetts and New Hampshire, I had been much puzzled by measurements, evidently intentional and rather regular in their discordance, showing reference to some other scale of linear measure, and giving apparently evidence of a near accordance with the English foot. In trying them with the old Mexican foot and inch scale, I found some excellent accordances; and it may turn out, remarkable as it may seem and bearing important results, that at the time of the mound-builders, 1,000 to 2,000 years ago probably, there co-existed over large parts of North America at least two distinct sets of linear measures, probably used by different races of people; and that one of these was no other than the identical one we have shown to exist, probably at a somewhat later period, in Mexico and Peru. There is no space for me to go fully into this subject at the present time; but in part confirmation of it, I must go back to the Cincinnati stone tablet of measure, to which I have already referred. It struck me that the two sets of scales, one at each end of the tablet, might refer to these two scales, and prove to have been intended as a mode of comparison between them; and that solution of the question appears to be the correct one, after a protracted investigation of that curious and puzzling instrument.

Without a figure or drawing of the tablet, it is not easy to give a very clear description of it; but it may be stated that the six larger divisions on the left hand are in length precisely equal to two Mexicain inches, or $\frac{1}{8}$ of a foot, consequently each equals $\frac{1}{3}$ of that inch, and that they have attached to them a decimally divided scale of twenty smaller divisions, over and beyond which, at each end, are two more similar small ones, apparently so placed as a mere stop-gap, or for symmetry. On the opposite end are 7 larger divisions, each a trifle smaller than those on the other side, in connection with 23 smaller sub-divisions and one over. The first 6 of these 7 are precisely 2 inches, and therefore also $\frac{1}{3}$ of what I have little doubt had reference to another co-existent unit of measure, which I call the North American prehistoric unit, and which I have likewise found to measure with great exactness several objects, notably several stone tubes, some objects in Squier and Davis' museum at Salisbury and also certain figures given in Abbott's "Primitive Industry" and the Peabody Museum Reports, as gorgets, pendants, etc., etc. Of this measure there are as nearly as possible 13 to 12 Mexican, and 11 to 10 English, and 6 to $6\frac{1}{2}$ of the smaller or mound inches, while $6\frac{1}{3}$ of the larger divisions on this scale are equal to the 6 larger Mexican ones on the opposite or left-hand side of the tablet. This prehistoric inch is intermediate, in fact, between the mound inch, as indicated by the tablet itself, and the Mexican inch. Whether 11 or 12 of these inches made the foot I cannot certainly say, though probably 11. That is, perhaps, a rather unusual multiple; but $5\frac{1}{2}$ inches exactly measure the tablet itself. Mr. Petrie gives 11.66 English inches as a Celtic and old Aryan prehistoric unit, also 22 inches, and I have found a unit pointing to 33 inches in Polynesia. There can be no reasonable doubt that this tablet was one of measure, and had reference to at least two distinct units of linear measure, used probably by the mound-building workmen. The tablet itself, of course, representing another and different one, the mound-builder's doubtless *par excellence*, with its own standard or unit inch, does not tally with the two scales referred to, engraved on its upper surface, one of which almost certainly represents the Mexican measure, the equivalent of the so-called Solon's foot. As 7 mound are just equal to 6 Mexican, it is not unlikely that reference was intended to that proportion;

the 7 larger divisions (=23 ° smaller) are as near as can be =2½ mound inches; but that multiplied by 2 or 3 does not, however, give an exact half-foot. It must be borne in mind, also, that as the mound-builders were skilled in square and circle mensuration and circumvallation, it is possible some reference to the well-known ratio of 3 to 1 might even have been intended in connection with circumferences of circles and their diameters, or possibly with diagonals and diameters; for opposite each of the larger divisions there are on an average 3⅛ smaller ones. Supposing, say, that the fourth division meant 400 feet (of either scale), then 400 × 3·3 might roughly have stood for the more exact 3 to 3·14. This is, however, a less likely explanation than the simpler one—viz., that the tablet was a half-foot measure, showing two or three different co-existing linear units of measure, used by several neighboring or allied peoples. The whole of this tablet is most curious and important, and so far has never been explained. On the reverse side of the stone are three large rough grooves, evidently made by the sharpening of some pointed tool. Involved with the scroll pattern on the upper side may be noticed seventeen small bosses or centres, many of which give, very exactly, distances apart of one inch, both mound and Mexican. The pattern itself may be semi-Mexican.

As no mound measures, so far, have been found in Central America, Peru, or Mexico, it would follow that in all probability the mound-builders themselves neither migrated there nor came from thence; and it confirms the opinion that the Toltecs and ancient Mexicans came in all probability from the North, as has generally been indeed supposed; but what is most interesting would seem to follow, viz., that the mound-builders, and the people allied to, or the ancestors of, the Toltecs, etc., must have, perhaps some two thousand years ago, coexisted and lived together in large parts of America, extending from New York to Ohio and Tennessee, and not been exclusively confined to the mound district *par excellence*. In fact, objects giving mound measures seem to occur in New Jersey and the New England States, and each set of people used their own peculiar standard of linear measure, consisting of twelve smaller or larger inches to a corresponding smaller or larger foot, probably employing also a 10 or 30-foot measure, and having a fixed acre with side of 300 mound feet, or

250-260 Mexican feet: unless, indeed, they may possibly have had for larger measures one and the same standard. But that may require further investigation. For convenience, I here append the length of the inches I have been referring to, along with the English :—

_____	Mound Inch, N. America, 12 to foot = a finger breadth, or 1 digit. Foot = ½ cubit (?).
_____	Prehistoric N. American Inch, 11 to foot (?).
_____	Mexican, Peruvian, and N. American Inch, 12 to foot = Solon's foot, or Roman.*
_____	English Inch, 12 to foot.

I have a gorget from Ohio precisely six Mexican inches in length. A number of objects mentioned in Dr. Abbott's "Primitive Industry" appear to give excellent Mexican scale measurements—pp. 144, 374, 383, 381, 373, 352, 330, 71, etc. The notches and distances of holes in gorgets, pendants, etc., will, I believe, often give either mound or Mexican inches. And, in fact, I hope that by means of these three scales or systems of measure for ancient America, when fully worked out, a flood of light may be thrown upon the habits and implements of her ancient peoples, possibly indicating how they may have been related to each other or to the Old World.

5. *China and Japan.*—There appear to be several different foot and inch measures in China and Japan. According to Mr. H. Seebohm, the Chinese and Japanese have a foot decimally divided, exactly equal to our English foot. According to Williams, a good authority, the *chih* = 13⅓ English inches, but others also = 14·1, 14·62 to 14.81. He elsewhere gives also an inch = 1¼ × 10 = 14·0 inches English. On an old foot rule (of bamboo) measure in the British Museum I find it so divided; and on a new Japanese foot measure the inch = 1½ English × 10 = 15 inches. There can be little doubt, however, that the best and oldest measure in China is the foot = 12 English inches, ·305 metre, decimally divided into 10 inches of 1·25 English. But what is of considerable interest, as showing that this unit was not recently borrowed direct from Europe, I have found that it must have been a measure employed without

* The Mexican inch is exactly $\frac{1}{12}$ of the foot (4 palms) of ·300 metre as derived from the Egyptian cubit of ·525 metre.

change two thousand years ago in the manufacture of what is called sword money! These appear generally to measure very precisely 6, 5, and 4½ of these Chinese inches, and it is a point that will, I think, bear fuller investigation. The oldest round bronze *cash* that is in my own collection, said to be B.C. 200 measures precisely one old Chinese inch across. The old Chinese inch = 1·25 English; and Mr. Seebohm believes that this old Chinese, as well as perhaps the English foot itself, may be derived from an Assyrian or Babylonian cubit of ·533, as given by Lepsius, thus:—

(Royal cubit 6 + 1) = 7) ·5330
·0761 = palm.
4
·3044

Anything throwing light on the early connection between Babylonia and China or other countries cannot, at the present time, fail to bear good results.

6. *Mongol.*—At p. 316 of Col. Yule's "Travels of Marco Polo" is a description and figure half-size of a most important specimen of what is called a "Table d'or de Commandment," the *Paiza* of the Mongols. It is of the fourteenth or fifteenth century, having engraved on it letters in the Baspa character. This is described by Schmidt as measuring 12·2 inches long, by 3·65 wide; and by Ramusio as a cubit in length and 5 fingers wide, and as weighing between 24-32 ounces. This tablet was found in the Government of Yenesei in Eastern Siberia; and being so important an object, perfectly finished and of solid silver gilt, and running so near the old Chinese foot, viz., ·311 metre as against ·305, it should receive some attention as having been possibly cut or cast by the measure of the then existing Mongol foot, or as part of some cubit. This tablet measures 8 $\frac{9}{16}$ inches of the newer and larger Chinese measure.

7. *Hittite.*—In looking over the plates in Dr. Wright's "Empire of the Hittites," recently published, it struck me that the apparent regularity of the spaces and lines, which divided the rows or parallel series of enclosed hieroglyphs, might furnish indications of some fixed measure, possibly in connection with

the old Assyrian or Greek. Mr. W. H. Rylands, secretary of the Biblical Archæological Society, kindly sent me a number of these measurements from the so-called Hamath stones; those of the Jerabis stones I have not yet received. The results are interesting; the average space, with a few very irregular, exceptions, gives exactly $4\frac{1}{4}$ English inches. Multiplied by 3 this would give a foot of $12\frac{3}{4}$ English inches, or ·323 metre, probably derived from one of the old Assyrian cubits. Mr. Seebohm, who has thoroughly gone into the question of ancient cubits and feet, informs me that this is almost identical with a foot derived from the Olympic cubit, say of ·320 metre. The Hittite foot of $4\frac{1}{4} \times 3 = ·320$, *i.e.*, 1-600 part of the Olympian stadium. Prof. Lepsius gives the Babylonian cubit as:—

$$\begin{array}{r} \text{Cubit} = .5333 \\ \qquad\qquad 6 \text{ rods or reeds} \\ \hline 3.2000 \times 60 = 192 \text{ stadia.} \end{array}$$

This, if treated as a decempeda, gives a foot of ·320. This, if fully confirmed, is of singular interest in connection with Babylonian, Assyrian, Hittite, and Greek civilisation and ancient inter-communication, a subject at the present time occupying considerable attention.

There was, I understand, from Mr. Seebohm (see also Mr. Petrie's "Inductive Metrology"), another old Assyrian cubit, equivalent to ·560 (? = the modern Persian), which, treated as a decempeda, gives another foot of ·325; and the same as what is called the Drusian, or Old Belgic, foot. Mr. Seebohm further alludes to Herodotus as stating that the foot = 4 palms out of the seven (*i.e.*, 6 + 1).

$$\begin{array}{r} \text{The cubit of 7} \quad \overline{·560} \text{ palms} \\ \overline{·080} \times 4 = ·320. \end{array}$$

I hope at a future period to go more fully into these questions, and to give fuller illustrations and figures. In the meantime, I content myself with stating what appear to me to be sufficiently well authenticated results on somewhat novel ground.

8. *Buddhist and Indian.*—There would appear to be considerable uncertainty, as well as variety, in connection with units of measure in Persia and India, more especially in comparatively modern times, since the introduction of Mohammedism and the employment of European architects.

In Petrie's "Inductive Metrology," p. 129, there are given no less than fifteen varieties of the so-called *gaz*, *guzze*, or cubit, varying in length from 14·9 to 38·3 inches. In more modern times the ½ *gaz* is also common = 6·93 inches. The *hasta* Mr. Petrie considers to be a very ancient Aryan measure, sometimes found in Greece and Asia Minor as = 17·9 inches; but in India it may be reckoned at about 18·4 inches. Another unit is 11·63 inches, which may, perhaps, be referred to the Roman foot in Mohammedan buildings in Turkey and Persia, where the Greek or Roman Empire extended.

Mr. James Fergusson informs me that no ancient buildings of India are set out with sufficient exactness to recover a measure from them, which may even apply to buildings of the time of the Mogul Empire, when Europeans were employed. It is nearly impossible to ascertain the length even of the Illahi *gaz*, and it might almost seem that the Hindoos never employed any other "rule" than the cubit or forearm of the reigning king. Mr. Petrie, however, gives the Illahi *gaz* = 34·1 inches English = 41 digits; and it has probably nothing to do with the digit of the early Hindus, which is connected with the *hasta*, though it would come to about the double of it.

It is difficult to suppose that the old Assyrian cubits of 19·04 and 19·97 inches did not find their way into India by way of Persia, either directly or indirectly, but they may have been modified, or carelessly applied; the sacred or royal cubits of 25·3 too were larger. I have taken from Mr. James Burgess's "Archæological Survey of Western India" about 250 measurements of from 2 feet to 100 feet; most from early Buddhist shrines, cells, temples, and caves, as those of Elora, Anka, Kaladgi, Badamj, Bhâjâ, Kuda, Gumli, Sana, Junagarh, Navalakha and Aurungabad, say A.D. 200 to A.D. 1200. On tabulating these measurements, I found a decided tendency to maxima and minima grouping of nearly five English feet; giving, say, for maxima, the Nos. 60, 56, 51, 47, 42, 37, 32, 27, 22, 19, 16⅓, 12¼, 7½, 4⅜, and 2·7. After trying various cubit lengths, say, of 17, 18, 19 and 20 inches, I found that a cubit of almost exactly 19 inches suited best for a series of most likely cubits, giving, say, 38, 35½, 32½, 30, 26½, 23½, 20½, 17, 14, 12, 10½, 8, 6, 4½, 2½, and 1·7, apparently pointing to a series showing differences of 3 cubits, which

would be best represented by the series of 39, 36, 33, 30, 27, 24, 21, 18, 16½, 13½, 10½, 9, 7½, 6, 3½, from 40 to 20 cubit lengths, where a half-rod might have been employed, and for the smaller lengths perhaps a quarter rod, or 1½ cubit measure. Here 4¾ English feet = 3 cubits = ½ rod, and 9½ = 6 cubits = 1 rod. From 45 special measures of dagobas, shrines and chakras, I obtained about the same 19-inch cubit.

It is, however, hardly to be expected that the same exact cubit or measure should have been constantly employed over a period of 700 or 800 years, even in the same part of India. In further corroboration of a probable earlier Buddhist unit of about a cubit of 19 inches, I may mention that Williams gives the Japanese *thuoc, chih* or cubit = 17·12 inches English, specially used by architects. This may have not improbably been introduced by the Buddhists more than 1,000 years ago. Again, in Java, I have got from Raffles' descriptions of old Buddhist or Hindu temples, probably free from European or Mohammedan influences, some 90 measurements, showing apparent favorite maxima numbers of about 3¼, 5½, 6½, 7¼, 10, 11½, 12¼, 16, 20, 21, and 30 English feet, which would again seem to suit best a cubit of 19·20 inches, giving roughly say 2, 3½, 4½, 6½, 7, 8, 10, 13, and 20 cubits. Here the smaller measures given by Raffles, *e.g.*, below 2 feet, of 12, 12, 14, 14, 16, 18, 20, 24, 26, 26 inches indicate a very regular gradation of 2 English inches, probably = 2½ digits. At the same time the old Indian *hasta* might also yield for 6½, 7¼, 10, 11¼, 12 and 20 English feet, very nearly the numbers 5, 6½, 7½, 8, 9, and 15.

From some measurements connected with the Amravati tope, Madras Presidency, I get a small *hasta* of 16·25 inches, for large measures, and of ½ = 16·0, from a number of smaller measurements of plinths, tablets, etc., in the British Museum. The two large feet of Buddha from the same tope measure 20 inches in length. From some larger cave-temple measurements at Adjanta, second to tenth century, mentioned by Fergusson in his "Handbook of Architecture," I get a unit of 17·8 inches, probably the *hasta* of 17·82 as given by Petrie as a unit of some measurements at the Elora cave temples. One of the oldest Buddhist topes in North India, near Peshawur, is said to be about 20 feet in diameter, which might also indicate a small *hasta* of about 16 inches.

From 12 measurements of old buildings in Ceylon given by Fergusson, I deduce a unit of 22·1, which does not fit precisely any known measure, though near the prehistoric one of 22 inches, and an old Assyrian cubit of 21·30 as given by Petrie, but it might possibly fit equally well a *hasta* or *aratni* of 16·5 inches.

Of course a good deal in these matters must depend on the respective dates of the buildings themselves, and in what part of India they are situated. I have been attempting to deal rather with old buildings, prior to the twelfth century; and the general results appear to indicate a cubit of 19.1 inches, and a *hasta* of about 16½ inches, very near Mr. Petrie's *aratni* of about 16·6 to 16·8 inches, and also, I believe, identical with Warren and Conder's latest determination of the old ordinary Hebrew cubit.

9. *Prehistoric Measures of Bronze and Stone Period.*—The entire question of prehistoric units, as distinguished from the older and more classical measure units of Egypt, Assyria, Greece, and Rome, requires a more thorough examination than it has yet received. Mr. Petrie, in his "Inductive Petrology," gives a very common and apparently well-established prehistoric (? Celtic) unit of from 21·30 to 22·50 as obtained from the ruder stone monuments of France and Britain, etc.; and for Irish bronze weapons 22·0 (as from 2·20 inch objects probably). The half of this would show a (? foot) measure of about 11·0, too small to agree with the old Roman foot of 11·60 to 11·70 not unfrequently found in Great Britain in connection with old Druidical remains, as even at Stonehenge. This unit, or half unit of 11·0, is, however, by no means, uncommon, and may prove to be of considerable importance. May not this old Aryan foot of about 11·0 inches, found in North Europe and elsewhere, prove to be the identical unit which in my first letter I called the North American prehistoric one? On scaling $\frac{3}{4}^{2}$ = 11 into twelve equal parts the result is a foot, barely the one eighth of an inch less than my American one, as indicated by the Cincinnati double-scaled measure-tablet. I most unexpectedly came upon this conclusion from a quite independent investigation of objects from North Europe of the bronze period, described by Evans, Keller, Madsen, and Montelius, as well as from specimens in my own collection. It is, therefore, not by any means improbable that there was at a very early period, before the superior civilisation of

Egypt and Assyria had begun to extend itself to other parts of the globe, one, if not two, rather widely extended primitive units of linear measure in existence, which spread over the New World as well as the Old, but which also probably, as time advanced got modified or mixed up with other units.

I have likewise found rather strong traces of the North American mound foot of ·254 metres, as well as the Mexican or old Roman foot of ·268, occurring in North Europe in the bronze age. That the Roman foot is frequently met with in Europe, and occasionally even in the East, is a well-known fact, and easily to be accounted for.

The following is the analysis of some 360 measurements of bronze objects I have collected from various sources, and is, at least, curious; probably three fourths of the objects measured, or figures examined to scale, gave good results to one scale or the other, say, to very nearly round inches and half inches.

	English Inches.	Mexican or Roman.	Mound Inches of N. America.	Prehistoric Inches, N.A.
Scandinavian objects	6	5	16	22
Swiss Lakes	13	9	9	17
Evans's Bronze Age, British.....	14	16	25	29
R. P. Greg's Collection, Miscellaneous..	33	30	50	68
Totals.....	66	60	100	136

Mr. Petrie gives 2·20 as an average of Irish bronze objects, which would be almost exactly 2·5 of the prehistoric scale.

The large proportion agreeing with old American measures is very remarkable, making considerable allowance for accidental coincidences, and looks as though two, if not three, prehistoric standards of linear measure were once more or less prevalent over a very large area. The Mexican or Solon's Roman foot may have been derived from the Old World, very possibly from an Egyptian cubit, some thousands of years ago. I have largely tried decimal scaling, but do not find that the larger inches agree nearly so well as those taken by duodecimal division also, for

bronze objects, a scaling from an Etruscan unit of ·230 mentioned by Petrie, but with very few accordances.

The few measurements I have been able to collect with reference to the stone and bronze age in India do not lead to great results, but may be worth giving. The remarkable and almost unique series of bronze celts found at Gungeria in Central India, and now in the British Museum, give lengths for the larger ones 17-27 inches; averaging about 21½, which comes very near Petries' 22·0 prehistoric unit before referred to. The smaller ones range from 4½–8¾ inches; the average being about 5½ inches, × 4=22; which again is in accordance. They have possibly been hammered out, or subsequently cut, acccording to Mr. Franks.

In Breek's account of the Primitive tribes (Todas, etc.) of the Nilgiris in South India are figured several cromlechs, on some of the upright stones of which are sculptured rows or series of figures in relief. The average width of these rows and divisions gives about 1·15 metre=45 inches, which divided by 2 would give 22½, again an excellent accordance with Petrie's 22·0 unit, and four times my prehistoric foot. I have also got 33 inches for a number of objects from modern Polynesia, which is, of course, a multiple of 11·0. The diameter of a hole at Kakusi, in India, in a *kistvaen*, is about 44 inches. It is doubtful if this apparently old Aryan and worldwide prehistoric unit of 11·0 inches has any connection with the *hasta* of 16¼ — 18½ inches.

Whether there is anything in common in the dimensions of Indian cromlechs, dolmens, and stone circles with those of Europe, I cannot at present say. The proportion for prehistoric as compared with English measurements should be as 12 to 11. Waring gives 19, 27, 45 and 66 English feet for some small stone circles in India, which would give in prehistoric feet a close approximation to the very likely round numbers of 20, 30, 50 and 70. Mr. Ferguson also, in his "Rude Stone Monuments," p. 474, gives two common dimensions of a class of small stone circles as 24 and 32 feet diameter, which would give 26½ and 35 prehistoric feet. The age, however, of this class of stone monuments is uncertain, and varies greatly, and may even not be pre-Buddhist; but it is very probable that there may have been some pretty accurate standard or standards of linear measurement going back to at least the commencement of the bronze period,

which are well represented by some of the measures I have been considering.

10. *Oceania.*—From about 20 measures of old stone ruins in Microlesia and Easter Island, as given by Wallace and Palmer, I have obtained an apparent unit of either 8 inches, a probable span; or else one of about 12 English inches, or very near the Mexican foot, neither of which, however, would agree with my prehistoric foot of 11 inches. But from a few measures of somewhat similar ruins in the Sandwich Islands given by Ellis, Mr. Petrie obtained a unit of 44.65, which would be a good multiple of that foot.

P.S.—With reference to the Cincinnati tablet referred to in my first letter, I should have mentioned that there is a very slight difference in the length of the two supposed standard inches, amounting for 3 inches to $\frac{1}{8}$ of an inch. I fancy this must have arisen accidentally, and was hardly intentional, since, for a half-foot or foot, it is not nearly sufficient to give even the prehistoric foot, much less the Mexican, nor any of Mr. Petrie's. I therefore averaged the length of the two, which gives excellent results, so far as the tablet itself is concerned, and for various mound objects, such as tubes; and I may add that the 7th larger division of the right hand scale might have been added to fill up the smaller space, as compared with the six rather smaller divisions on the opposite end, meaning merely a seventh prehistoric inch, or $\frac{1}{7}$ of it. A foot of $7 \times 2 = 14$ mound inches would hardly be a likely one, though it would come within $\frac{1}{5}$ of an inch of Mr. Petrie's mound builder's foot unit of 12·60, and would fairly measure a very long stone tube of $12\frac{13}{16}$ inches in the Salisbury Museum, but no other object that I have come across.

With respect to Mr. Petrie's unit of 12·60 for the larger mound measures, I am now investigating it more particularly. It measures no small objects, however, and, so far, I think, with a few exceptions, does not give such good results as my own unit of 10·0 English inches. Mr. Brinton of Philadelphia states that, in 1881, Prof. McGee applied Mr. Petrie's arithmetical system of inductive metrology to a large number of mound measures of Iowa, with the result of a common standard of 25·716 English inches; that is $=32$ of my mound inches, or very nearly $10 \times 3 = 30$; agreeing pretty well with Col. Whittesley's conclusion that, for the

Ohio mound works, 30 inches was about the length, or was one of the multiples of the metrical standard employed. For various reasons it may even be doubted whether any small unit, or too strictly scientific method, will be found to give uniform satisfactory results for these mound measures of North America. The mere circumference or diameter must necessarily have varied with the height, as far as mere mounds were concerned, which ranged from 10 to 100 feet; it is not unlikely, too, that, in constructing their enclosed "sacred" areas, they may not have sometimes intended to construct a circle, say, to measure to a certain square area, or the reverse, in which case too much importance should not be attached to the circumstance that a circle diameter of exactly 1,050 feet should = 1,000 of Mr. Petrie's unit, on which he lays much stress, and which, according to my scale of 12 to 10 would show 1,300 feet—a less likely round number perhaps. There are, however, no fewer than eight cases, where no equal squares are in question, given by Squier and Davis as having the diameter of 250 feet, which would give exactly 300 of my mound feet, and a much more likely number than Mr. Petrie's unit would give, viz., 240. Quite probably, too, all North American mound measures cannot be dealt with by one unit of measure only. Those in the lower Mississippi Valley may be found, perhaps, to give more purely Mexican measures. The pyramid of Teotihuacan has a gallery of 157 feet long = 160 feet, springing from a height from base of 69 feet = 70-71 feet. That of Cholula, of 1,450 feet square, would give 1,500, and that of Sonora of 4,350 feet exactly = 4,500, according to Solon's foot unit.

I purpose to examine more thoroughly Mr. Petrie's units of 6·76 and 10·65 as applied to Mexican and Central American measures. Of those from Peru, Copan, and Palenque, I think that there Mr. Petrie's units may be the best. For Aztec Mexico itself, I do not find that they suit so well as Solon's foot of 11.70. The body of the great temple at Tiahuanaco, in Peru, is given by Squier as 388 × 445, which, with 2 or 3 per cent. added, would give 400 × 450. A circular stone building near Cuzco, in Peru, of 24 feet internal diameter, and one in Central America of 48 English feet, look very like 25 and 50 feet, by my Mexican measurement.

Dr. Brinton also states that Señor Almarez, in 1864, specially

determined the probable old metrical standard for the ruins of Teotihuacan, and made it about 0·8 metre = 31·5 inches, which is not far from Mr. Petrie's for Central America and Copan, if 10·65 × 3 = 31·95; though it is also very near an even $\frac{1}{8}$ of the *Octacatl*, to which I have previously referred.

There is, doubtless, room for further investigation in respect to these old American measures.

VI. Traditions of the Ainos of Northern Japan.*

By D. P. Penhallow.

Tradition is the unwritten history of a people, transmitted from one generation to another by word of mouth, and from its very nature is not altogether reliable, but in the absence of any testimony of a more exact nature, must be given some weight as affording an approximate clue to the history of the people concerned.

When traditions relate to historic periods, they may often be verified in many particulars; but when they deal with periods which antedate all written records of a contemporaneous people, verification is hopeless, and they must be accepted for what they are worth. Thus it is with the aborigines of Japan. Japanese history extends back to about B.C. 200 or B.C. 400, but many of the Aino traditions relate wholly to a much earlier period. Those which fall within the historic period of the Japanese can in many cases be verified by the history of the latter.

Handed down through a long series of generations, traditions, however well founded upon fact in the first instance, ultimately lose much of their value, and may often become wholly different in substance from those originally given. This is more conspicuously the case as time passes. Passing events must leave a certain impress upon the mind, which will, in the course of a few years be-

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* The Author was for four years resident in that part of Japan where the Ainos are now most numerous, and, in his journeys through the country, had numerous and exceptional opportunities of learning their habits and language.

come confounded with the traditions received and ultimately be repeated as a part of them. This is likely to occur when a people is isolated; but it is yet more likely to happen, when a dominant race intrudes and displaces the original inhabitant. His ideas will then be influenced to a perceptible degree by those who displace him. This result is manifest in many of the traditions held by the Ainos. Undoubtedly sincere in the belief that such statements were handed down as true facts of their own history, their holding them can be accounted for in no other way. Thus, the tradition of their origin from a dog, related in good faith by the Ainos themselves, is most undoubtedly, as many Japanese acknowledge, a fabrication of the latter to express their contempt for, and sense of superiority to, the former.

In spite of this, however, tradition must form not only an interesting but important part of ethnological studies, and it is for this reason that the following are here placed upon record, since they relate to a most interesting remnant of a people concerning whom but little has been written until within a few years.

According to their established traditions, the origin of the Ainos is traced to an outcast woman, who came from some country toward the West. Attempts to account for her ancestry generally credit her with being the daughter of a ruler of a not far distant country. One version, in which she is the daughter of an Asiatic ruler, makes her the persecuted object of her father's lust; and it is to escape from this that she seeks voluntary exile, by embarking alone in an open boat with a large white dog as a companion. The filial reverence of the child, however, gains the supremacy in her solitary exile; and owing to her cherishing the name of her father Kamui, and instilling thoughts of reverence for his name into the minds of her children, he becomes more and more an object of reverence, until he is finally deified, under the slightly modified name of Kamoi, which is now applied to all the Gods of the Ainos.

Another and very common version places Jinmu Tenno, the founder of the Japanese, as the primal ancestor. This, however, throws undoubted discredit upon the tradition, as proving its relatively modern origin. However, in this case, the daughter became the object of her father's displeasure, and was forced into

unwilling exile by him. He had a rude boat constructed, and in this his daughter was placed, together with a sword * and some food. After drifting about for some time, generally said to be three days, she was finally cast ashore upon southern Yezo. Here she built a round house † and formed an attachment for a white dog. The Ainos were the result of the union. Interesting as it would be to know, tradition fails to enlighten us as to the name of this founder of the Aino race.

Other versions are not wanting, and at times they receive extended embellishment at the hands of writers, which materially alters their form. One such is given by Wood ‡ as follows:—

"Their story places a woman as the first of their race, and she came, as they say, from the West. This was soon after the world was formed out of the waters, which is the genesis of their cosmogony. The Ainos know of no land except islands; so that really this might be the form which tradition has taken since that remote period when the Isles of Japan and the Kuriles were forced up, as they appear to have been, by volcanic action from the Ocean bed. The Ainos tell how this woman, the first of their race, floated over the waves in a vessel freighted with bows and lances, with nets and lines, and with all things necessary for the chase and fishing. She landed on an island where was a beautiful garden, and in it she dwelt alone and happily for a long period of years. That garden still exists, say they, but no living man has yet been able to find it. The close of this reign of single blessedness, so long enjoyed by this first of the Amazons, was brought about by a singular circumstance, which, however, can scarcely be narrated here. There is not, as in most legends, the record of a broken commandment, though transgression of some kind is implied: the change being connected with the loss of the garden and the increase and dispersion of the race. These events

* A facsimile of this weapon, supposed to have been made under the direction of the ancestral mother and handed down by her, was obtained at considerable expense by me, and is now to be found in the collection at the Peabody Museum, Cambridge, Mass.

† Evidence that the early form of the Aino house was round is not wanting; such houses are said to be used occasionally at the present day, though I never saw one.

‡ Trans. Eth. Soc., New. Ser., Vol. 4, p. 34, etc.

followed after the advent of a self-imposed protector whom the lady of the isle had, in a period of weariness, permitted to enter and share her solitude." *

As her family increased, rules for their guidance were established even in the most trivial affairs of every-day life, while the Ainos held their ancestor in such reverence that, to this day, the laws first established by her and the directions then given are implicitly followed.

It is related that she generally wore long and flowing hair, but that she finally trimmed it by placing her head upon a block when the hair was cut to a uniform length all round, by use of the sword. In obedience to her commands and example, her children trimmed their hair in similar fashion, and this, in all its details of method and form, is practised at the present time. Thus may we account for the peculiar square-cut of the hair, which is so conspicuous in and uniformly characteristic of the Ainos.

A second command was to the effect that her children should follow the customs of the Japanese in all things. This is certainly in keeping with attributing their primal origin to the founder of the Japanese, though it certainly impresses one as more than a passing indication of the influence which a dominant people may exercise upon the thoughts of those directly subject to their control, and shows what influences have been brought to bear to keep the Ainos in subjection, and to impress them with a sense of their own inferiority.

Rather amusing is that tradition which attempts to account for the custom of tattooing the lips, so prevalent among the women. Evidently the ancestral mother had a strong inherent love for the sterner sex, which was not weakened by her father's displeasure, but was rather heightened by separation from him.

* This tradition appears to have been given variously at different times, since in my own experience in gathering information from old men of the various tribes, reputed to be well learned in all the customs and traditions of the people, I have been unable to hear of a garden or of a greater number of implements than those first mentioned. To my mind, simplicity of detail seems to commend the tradition, as more probably correct than that version which included so many statements so nearly and singularly in accord with the facts of our own history.

Observing the abundant growth of whiskers which her sons developed, while the daughters were entirely destitute of such desirable adornments, she commanded all her girls to paint their mouths, and thus simulate the appearance of their brothers. Tradition is not consistent in this account however, for at least two other equally reliable versions are given. One relates that, in olden times, when the people were more generally engaged in fishing, and at a time when the physical character of the country was far different from what it is now, many men and women were drowned, and as a ready means of identification, the custom of tattooing the lips was gradually adopted. Another version tells us that, before the Japanese began to settle in Yezo, they would often visit the island and carry off the women. The Ainos did not possess the means of successful physical resistance, and determined to resort to other methods. The women were therefore tattooed, in hopes that their appearance would thereby be rendered so repulsive as to deter the Japanese from their capture. This version certainly is more in accord with facts relating to the settlement of the island, and is doubtless to be accepted as more nearly representing the origin of the custom than any other given.

The men were commanded to wear earrings and whiskers, as is now generally the custom. The *ekoro*, or sacred sword, appears to have been copied by the ancestral mother, and the various copies, together with the original, handed down to posterity as sacred heir-looms. So strong is the belief in this, that it was found extremely difficult to obtain one. It is reported that only a few are in existence.

The complete isolation of the Aino family from other peoples, necessitated the adoption of intermarriages, which, however, with the increase of families, became abandoned for a somewhat more rigid, though still loose, system, which recognized marriage only between families of somewhat distant relationship, but permitted concubinage.

The Ainos believe their first settlement to have been at Saru on the south-east coast, and there are certainly many evidences which point to this as at least their chief, and possibly one of their earliest, settlements. From there, they are supposed to have spread in all directions, but chiefly southward into Honshiu, where

they met the Japanese, and by them were repulsed and turned back into Yezo.

The belief seems to be general that the world is round, and that it is stationary, the heavenly bodies moving round it. The evidence they adduce in proof of this is that he sun and moon rise on one side and set upon the other. This tradition may have been borrowed from the Japanese, and obtained through the teaching of certain Buddhist priests; for although, until a very recent period at least, the idea was generally current among the Japanese that the world is flat, it has long been held by certain Buddhist sects that the world is round, and that the heavenly bodies alone move.

Volcanoes and earthquakes, and all manifestations of violent changes within the earth's crust, receive due explanation. The centre of the earth is supposed to be filled with water, and is generally regarded as an *inferno*, receiving, therefore, in allusion to its wet and undesirable character, the name of *Deni-Bokonashi* or "wet hell." This region is presided over by a huge fish, called *dokushish*. As he swims about and violently lashes his tail, striking it against the walls of the earth, the tremors produced are recognized on the exterior as earthquakes. There are places in the earth, however, which communicate with the interior where the fish dwells, and the latter is thereby enabled to exert his influence upon human destiny. Lake Chitocie is firmly believed to be such an opening, and so implicitly do the Ainos believe in the presence of the dokushish there, and his power to exercise an evil influence over them, that none will venture out upon the deep water. In my experience of the Ainos, though a boat was kept on the lake all the time, no one could be induced to leave the shallow water of the shore, for, said they, "if we go far out, the big fish will surely destroy us." So if one wishes to cross the lake, a distance of some seven or eight miles, he must submit to a circumnavigation. The destructive tendency of this great marine monster is said to have been demonstrated at the expense of many boats and lives.

The Japanese have a tradition very similar to this, at least so far as the cause of the earthquake is concerned; with them, the active agent is the *namadzu*, or cat-fish. This appears to be the same as the Aino dokushish, a fish which is very abundant in certain localities.

The chief evidence that the interior of the earth is filled with water, is in the springs and rivers which flow without ceasing and must have an abundant and common origin within. It has not been possible, however, to obtain a satisfactory explanation, which would reconcile this belief with the equally well-established tradition that there is an abundance of fire in the earth, as volcanoes demonstrate. In fact, no explanation whatever, is offered. It appears, however, that it is the volcanoes themselves which led the Ainos to give the interior of the earth the character of hell, and that both fire and water are in the centre is demonstrated by the hot springs to be found in various parts of Yezo.

There is one tradition, repeated with but little variation, which whatever its origin may have been, seems to be strongly in agreement with known facts as they appear in evidence of a geological nature. The Ainos' conception of the world seems confined to formations of an insular character, and doubtless originally embraced Japan alone, since we find their word *Moshiri* signifying both "world" and "island," and constantly used in this double sense. Upon this special point, moreover, no well-defined tradition seems to be current. There is one, however, to which we have already alluded, which bears directly upon subsequent changes.

Formerly, the present Island of Yezo was divided into two parts. An arm of the sea from the west penetrated the interior and occupied the territory now known as the Ishicari Valley. This met a similar body of water, which penetrated from the east and occupied what is now the Tokachi Valley—the two meeting at the present divide between Ishicaridaki and Tokachidaki, two of the highest mountains on the island. The fact that fossil marine shells are found in abundance in the upper Ishicari Valley and its tributaries, shows that the ocean did once cover this area; and whether or not the idea has been borrowed from the various foreign experts who have explored the island under government patronage of late years, the presence of these shells and the resemblance they bear to existing forms, is given by the Ainos as one of the strongest proofs in support of their tradition.

At the time of this separation, therefore, all the territory at present occupied by the Ishicari Valley and the two mountains south and east, was under water. The northern island was known as Maskishoya Ishicari, and extended from the present

mountains bounding the Ishicari Valley on the north, to Shoya on the extreme north and Mombetsu on the east. The southern island was known as Mado-mai, and embraced the territory from Chitocie Lake on the north to Hakodate and Matsu-mai on the south. Tradition does not inform us as to the time which has since elapsed. After a time, however, there was a great earthquake, and the earth became violently agitated, being thrown up into great waves. This lasted for one hundred days. This unusual commotion caused the surface to be thrown up into great folds, and volcanoes and mountains to rise where plains had been known before. The first volcano to appear was that near Usiu, and known to the Ainos as Abouta. The second was Sawara, on the southern shore of Volcano Bay; while the third volcano was Tarumai on the south-east coast near Tomakomai and on the eastern shore of Lake Chitocie. This general commotion furthermore caused a general elevation by which the islands became united. The name, Mado-mai, formerly applied to the southern island, now became the name of the southern district, but more particularly of a town on its southern coast, and this name, once distinctly Aino, became subsequently corrupted by the Japanese into Matsumai, by which the former capital of the island is now known.

By some it is related that the Ainos were always friendly toward one another, but united in their antipathy toward the Japanese, for whom they had a well-defined dislike. This tradition evidently relates to a period subsequent to the union of the two islands. Such a change might naturally be conceived to bring about conditions favoring amity, where before jealous rivalry alone existed; and this would be the more probable, if there were a common enemy to combat. It is very difficult to obtain any account which points directly to open warfare with the Japanese in the past, and there is a reserve thrown about any narration of this sort, as well as about the conveyance of information touching matters of present moment, which indicates a strong and inherent dread of their conquerors. If we were to give these traditions the weight of truth, that relating to amicable relations among the various Aino tribes, and combined enmity toward the Japanese, would seem to indicate that the geological changes here spoken of must have occurred before the Japanese occupation, for well-

versed members of different tribes, especially chiefs, related to me the tradition that, in very early times, the various tribes occupying the northern island were at war with those of Madomai. War parties frequently crossed from one island to the other on depredatory expeditions; but finally, when the land rose and united the islands, friendly relations were established among all the tribes.

With regard to the previous occupation of the country, I have found no tradition which bears directly upon that point. There is certainly no tradition crediting their ancestors with the construction of such mounds as are found at Otarunai and elsewhere. Neither is there any tradition concerning the manufacture of burnt pottery, and the general evidence seems to indicate that, the Ainos never possessed a knowledge of the art.

There is nothing relating to a language at all different from that now in use, and it is highly probable that written characters were never known or used. If they ever existed, they have been completely lost.

VII. Organic Siliceous Remains in the Lake Deposits of Nova Scotia.

By A. H. MacKay, Pictou Academy, N. S.

The siliceous deposits in the lakes referred to are, first, and most abundantly, of vegetable origin, consisting of the exquisitely sculptured cell-walls of the unicellular plants, constituting the order *Diatomaceæ;* and, secondly, of animal origin, consisting of the spicules which form the skeletons of that group of the fresh-water sponges known as *Spongillina*.

The investigation of the character of the lake deposits of Nova Scotia has only been commenced and much is yet expected to be brought to light. The explorations made during the last two summers include a large number of lakes throughout the province, varying from five miles in length to less than one half of a mile, and from 160 feet in depth of water to that of only six or seven. Deposits of some of the larger lakes have been examined, but no complete survey of them has yet been made.

These deposits may be roughly classified as follows:—

First, earthy muds.

Secondly, black or brownish slimy muds.

Thirdly, whitish siliceous muds, consisting nearly entirely of the cell-walls of the diatomaceæ and the spicules of fresh-water sponges, which are found to be present in classes *first* and *second* also, although in less comparative abundance.

These three classes, of course, shade off into each other without any distinct line of demarkation.

In the first class there is a variable quantity of fine sand or clay introduced in times of freshets when the water becomes discolored from the earthy matter borne into it. Deposits of this class abound in lakes into which large streams that readily become turbid flow; and they form more rapidly, it is presumed, than those of the other classes. Soundings in the upper portions of the Lochaber, Garden of Eden, Forbes, Ainslie and Grand Lakes, for instance, bring up material of this class, all abounding to some extent with diatom valves and sponge spicules. The depths of these accumulations our primitive boring apparatus would not allow us to fathom.

The second class of deposits is found in abundance in lakes fed by small streams in the forest. In Calder and MacKay Lakes, Pictou County, the former being a full mile in length, the water in no place appears to be over 9 or 10 feet in depth, the average being 5 or 6 feet. In the central portions of these ponds a pole was driven down by the hand from a raft to the depth of 20 feet without striking hard bottom. Nearer the margin, the borer after passing through this deposit, generally took up a stiff clay, which has also been found underlying some peat swamps in the neighborhood. In some of these swamps analysis has shown a large percentage of the incombustible residue to be composed of diatomaceous and sponge remains, thus demonstrating their lacustrine origin. When the hard bottom of the above-named and other lakes was found to be undulating, the light slimy diatomaceous mud was found to be deepest in the depressions,—the mud surface being more conformable to the surface of the water than to the surface of its bed. In MacLean Lake, less extensive but nearly 30 feet deep, the same characters of the bed of the deposit were observed. In most of the other lakes, soundings, but no

borings through the deposits, were made. The typical mud of this class is generally of some shade of a dark grey-brown color, having sometimes nearly the consistence of a very tremulous jelly, but pasty to the touch. Some specimens of this, dried so as to be so firm as to retain a moulded form, contracted to one tenth of its volume when perfectly dried, nearly 50 per cent. of which was estimated to be organic silica. While pieces of decaying wood, leaves, mosses, etc., are found in this material, its carbonaceous organic matter appears to have been to a great extent of algoid origin. The waters of these lakes are generally colored by the presence of organic matter in solution.

The third class of deposits has not been observed in such abundance as the other classes. In many cases it may have been formed from material of the second class, as is suggested by the deposits often shading off into each other in the same body of water. For instance, in Macintosh Lake, some of the purest white material did not come from the greatest depth of the water, but from the vicinity of shallows, between an island and the mainland. A gentle motion of the water from an exposed side of the lake is produced by the wind over this flat, and the deposit alluded to is immediately to the windward of the said flat. This suggests the hypothesis that the change from the slimy mud to the purer siliceous deposit may have been, at least partly, due to the solvent action of the water on the decaying vegetable material. This solvent action has been plainly demonstrated to exist by the analysis of the waters of the lakes which supply the city of Halifax with water, made by George Lawson, professor of Chemistry in Dalhousie College and University. The waters of Long Lake, the largest and highest of the series, was conducted for a time through the lower Chain Lakes, in which there is a large deposit of diatomaceous slime. The analysis gave 2.13 grains of organic matter per gallon in the water of Long Lake, and 2.68 in that of the lower Chain Lake. This shows that each gallon of water may have dissolved out of the Chain Lakes about half a grain of vegetable matter.

Those lakes, so far as observed, which lie in the midst of granite drift, and have clear water, have also purer silicious deposits, the percentage of silica in the dried material approximating in some ases to between 90 and 100. Folly Lake is an instance in which

much material of this kind is submerged, and near an affluent of Barney River is a good example of a deposit which is now left high and dry.

The greater proportion of this siliceous material is made up of the frustules or epiderms of about one hundred species of the diatomaceæ. The following have been provisionally determined by comparison with the mounted types of Möller, the plates of Schmidt's Atlas, Van Heurck's Atlas with 3,000 figures of Belgian forms, figures and descriptions by Brun of Geneva in his "Diatomées des Alpes et du Jura," and the descriptions of Rabenhorst in his "Flora Europæa Algarum Aquæ Dulcis et Submarinæ."

1. Cocconeis pediculus, *Ehr.*
2. C. placentula, *Ehr.*
3. Gomphonema acuminatum, *Ehr.*
4. " " *var.* coronatum, *Ktz.*
5. " " *var.* laticeps, *Ehr.*
6. G. cristatum, *Ralfs.*
7. G. gracile *var.* naviculoides, *Grun.*
8. G. abbreviatum, *Ag.*
9. G. capitatum, *Ehr.*
10. G. intricatum, *Ktz.*
11. G. cistula, *Hemper.*
12. Epithemia turgida, *Ehr.*
13. E. gibba, *Ehr.*
14. " " *var.* parallela, *Grun.*
15. E. argus, *Ehr.*
16. Himantidium arcus, *Ehr.*
17. " " *var.* majus, *W. Sm.*
18. " " *var.* tenellum, *Grun.*
19. H. formica, *Ehr.*
20. H. pectinale, *Ktz.*
21. " " *var.* ventricosum, *Grun.*
22. " " *var.* minus, *Ktz.*
23. " " *var.* undulatum, *Ralfs.*
24. H. soleirolii, *Ktz.*
25. H. bidens, *W. Sm.*
26. " " *var.* diodon, *Ehr.*
27. H. præruptum *var.* inflatum, *Grun.*
28. H. polyodon, *Brun.*
29. H. polydentulum, *Brun.*
30. Amphora ovalis, *Ktz.*
31. A. affinis, *Ktz.*

32. Cymbella gastroides, *Ktz.*
33. C cuspidata, *Ktz.*
34. C. ehrenbergii, *Ktz.*
35. C. lanceolata, *Ehr.*
36. C. delicta, *A. Sch.*
37. C. cistula, *Hemper.*
38. C. heterophylla, *Ralfs.*
39. C. tumida, *Breh.*
40. Navicula crassinervis, *Breb.*
41. N. gracilis, *Ehr.*
42. N. cuspidata, *Ktz.*
43. N. ambigua, *Ehr.*
44. N. appendiculata, *Ktz.*
45. N. affinis *var.* amphirhyncus, *Ehr.*
46. N. transversa, *A. Sch.*
47. N. amphigomphus, *Ehr.*
48. " " *var.*.....?
49. N. limosa, *Ktz.*
50. N. firma, *Grun.*
51. " " *var.* hit(s)chcockii, *Ehr.*
52. N. legumen, *Ehr.*
53. N. dicephala, *Ktz.*
54. N. elliptica, *Ktz.*
55. N. radiosa, *Ktz.*
56. N. scutellum, *O'Meara.*
57. Pinnularia oblonga, *Rab.*
58. P. viridis, *Rab.*
59. " " *var.* hemiptera, *Rab.*
60. P. perigrina, *Ehr.*
61. P. nobilis, *Ehr.*
62. P. major, *Rab.*
63. P. dactylus, *Ktz.*
64. P. gibba, *Ehr.*
65. P. divergens, *W. Sm.*
66. P. interrupta, *W. Sm.*
67. P. mesolepta, *Ehr.*
68. P. nodosa, *Ehr.*
69. Stauroneis phœnicenteron, *Ehr.*
70. St. gracilis, *W. Sm.*
71. St. anceps, *Ehr.*
72. St. fulmen, *Breb.*
73. St. punctata, *Ktz.*
74. St. stauropheria, *Ehr.*
75. Surirella robusta, *Ehr.*
76. S. splendida, *Ehr.*

77. S. biseriata, *Breb.*
78. S. bifrons, *Ktz.*
79. S. turgida *W. Sm.*
80. S. linearis *var.* constricta, *W. Sm.*
81. S. slevicensis, *Grun.*
82. S. elegans, *Ehr.*
83. S. tenera, *Greg.*
84. S. cardinalis, *Kitton.*
85. Nitzschia amphioxys, *Ehr.*
86. N. elongata, *Grun.*
87. N. spectabilis, *Ralfs* (?)
88. N. sigmoidea, *Nitzsch.*
89. Stenopterobia anceps, *Breb.*
90. Fragillaria construens, *Grun.*
91. " " *var.* binodis, *Grun.*
92. F. capucina, *Desm.*
93. F. undata, *W. Sm.*
94. Synedra ulna, *Ehr.*
95. Meridion circulare, *Ag.*
96. Tabellaria floculosa, *Roth.*
97. T. fenestrata, *Lyngb.*
98. Cyclotella operculata, *Ag.*
99. C. comta *var.* affinis, *Grun.*
100. Melosira distans, *Ehr.*
101. M. arenaria, *Moor.*
102. M. orichalcea, *Mertens.*
103. M. granulata, *Ehr.*
104. M. crenulata *var.* valida, *Grun.*

This list is not exhaustive of all the forms found in any given locality, much less of all the species in the lacustrine deposits of the province. Until the species have been more fully determined in the whole range of deposits there will be little use in attempting to compare the forms of the lower deposits with those of the upper or more modern. Great variations are observed in many species of the diatomaceæ, concomitant with their stage of development, and also probably with their different environments. The conditions of environment also affect their distribution. It is remarkable in the Nova Scotian species, so far as observed, that while most of the forms determined are also found in the distant waters of the Alps and the Jura, some of the deposits taken from lakes but a few miles apart can be distinguished by the presence or absence of certain forms or by their relative abundance.

This induction is as yet based on too few a number of observations to be of any scientific value. But such instances as the following have been observed: *Melosira arenaria* (Moor) is abundant in the Earltown Lakes near the summit of the Cobequid range of mountains; while Gulley Lake, a few miles on the other side of the watershed, is distinguished by the presence of *Stenopterobia anceps* (Lewis) Bréb.; and Mackintosh Lake, separated only by a few miles of mountain ridge and forest from both, contains, apparently neither this species of *Melosira* nor *Stenopterobia;* and the deposits of Lochaber lake are characterized by the relative abundance of *Cyclotella*. Of course these lake deposits contain, not only the organisms which live in their own waters, but those which are swept into them by their tributary streams.

In addition to the remains of the diatomaceæ, the siliceous spicules of sponges abound in all these deposits, especially the long skeletal spicules. In some few places, the silica from this source is in excess of that from the diatomaceæ. A search for the origin of these having been made last summer no less than *nine* species in *four* genera have been found, and two of these are considered as new to science. These fresh-water sponges grow on submerged wood, plants, stones and even on sand. They are all of some hue of green when living and exposed to the influence of light. They vary in size from very small up to a specimen of *Meyenia fluviatilis*, growing in Garden-of-Eden Lake, which measured twenty-seven inches in length by four inches in diameter, surrounding a small branch as a core. In the winter season the flesh of these generally decays, and most of the skeletal spicules scatter and accumulate in the adjacent deposits. The reproductive gemmules with their characteristic spicules, also, in the course of time float away, or germinate next spring on the original site. The following are the species of siliceous sponges which have been identified as living in the lakes at present, and whose spicules abound in the deposits under consideration. These sponges, like the diatoms, have certain species characteristic of certain waters, while others are more generally distributed.

1. Spongilla fragilis, *Leidy.*
2. S. lacustris *var.* dawsoni, *Bk.*
3. S. mackayi, *Carter.*
4. Meyenia fluviatilis, *Carter.*

5. M. everetti, *Potts* and *Mills*.
6. Heteromeyenia ryderi, *Potts*.
7. H. argyrosperma, *Potts*.
8. H. pictovensis, *Potts*.
9. Tubella pennsylvanica, *Potts*.

The first of these was described by Bowerbank as *S. lordii*. The specimen came from British Columbia. It was first discovered in England last summer, according to Carter. It turned out on examination, that Leidy, of Philadelphia, first described it as *S. fragilis*. No. 2 was described by Bowerbank over twenty years ago as *S. dawsoni;* next, by Potts as *S. lacustroides*. I called Mr. Potts' attention to Bowerbank's description, and it has been generally conceded since to be an American variety of the European *S. lacustris*. No. 3 was described by Carter, of England, in the January number of the "Annals and Magazine of Natural History," London. Potts claims that it is the same as his *S. iglooiformis*, a description of which, we think, has not yet been published. No. 5 is remarkable, as the species has never been observed before except in a pond upon Mt. Everett in Mass., U.S.A., at an elevation of 1,800 or 2,000 feet above the sea. It appears to be plentiful in Nova Scotia. No. 8, provisionally named, is remarkable for the paucity of its statoblasts, which for some time prevented its classification, although its skeletal spicules are very distinctive. Further investigation is necessary for the elucidation of the character and life-history of this species. This classification and nomenclature has the approval of H. J. Carter, the greatest living English writer on sponges.

E. Potts of Philadelphia, our best American authority, has observed that the spicules of sponges undergo variations within a very considerable limit, and that these variations are generally concomitant with the variation of the altitude of their habitat. The spicules of several of these Nova Scotian sponges he considers as varying from the usual type, but considers them as conforming to his hypothesis. The extensive deposits of these siliceous remains must have come proximately from silica in solution in the water. The analysis of the waters of Halifax lakes by Prof. Lawson shows the presence of soluble silica as well as of alumina, lime and iron, all of which have been found to exist in diatomaceous earths analysed by Zeigler, Hoffman, and

Lossier. No less than from 2.13 grains to 2.44 per gallon of these inorganic substances were found in solution in the waters of these lakes.*

VIII. The Classification of Natural Silicates.

By T. Sterry Hunt.

On pages 129 to 135 of the Record appears an abstract of a System of Classification of Natural Silicates, set forth by the writer in an extended essay "On a Natural System in Mineralogy, with a Classification of Silicates," presented to the National Academy of Sciences at Washington, in April, and to the Royal Society of Canada at Ottawa in May, 1885, and now in process of publication in the third volume of the Transactions of the latter. Accompanying the abstract, as printed in the Record, are three synoptical tables, which were but tentative, and, as the reader will have seen, not only incomplete but, as regards that of the Persilicates, in conflict with the text. These tables having been inserted in the abstract by an error, the present revised ones are given, which will shew more fully the system proposed.

Synopsis of the Order *SILICATE.*

Sub-order.	I. Protosilicate.	II. Protopersilicate.	III. Persilicate.
Tribe.	1. Hydroprotospathoid (Pectolitoid).....	6. Hydroprotoperspathoid (Zeolitoid).....	11. Hydroperspathoid.
Tribe.	2. Protospathoid.....	7. Protoperspathoid.....	12. Perspathoid.
Tribe.	3. Protadamantoid....	8. Protoperadamantoid...	13. Peradamantoid.
Tribe.	4. Protophylloid.....	9. Protoperphylloid.....	14. Perphylloid.
Tribe.	5. Protocolloid (Ophitoid).....	10. Protopercolloid (Pinitoid).....	15. Percolloid (Argilloid).

*This paper was written in answer to a request for the Author's observations on the diatomaceous deposits of Nova Scotia. It was simply given as a report of the progress of the Author's own work, which has since been extended to other portions of the Province, to New Brunswick, and Newfoundland. "Silliman's Journal," April, 1845, contains a list of twelve fossil infusoria determined by Professor Bailey in material sent from Earlton Lake by Sir J. W. Dawson. Of these, ten are now known as diatoms, and two as sponge spicules.

Suborder I.—PROTOSILICATE.

m : si.	1. PECTOLITOID. V=7·0—5·2	2. PROTOSPATHOID. V=6·7—6·0	3. PROTADAMANTOID. V = 6·0—4·6	5. OPHITOID. V = 7·2—5·5
1 : ½	- - - - - - - - - -	Danalite (7 : 6). - - - - - - -	Chondrodite.	
1 : 1	Calamine. Thorite. Cerite. -	Willemite. Knebelite. Batrachite. Tephroite. Gadolinite. Helvite.	Monticellite. Chrysolite. Phenacite. Bertrandite.	
1 : 1½	Chrysotile. - - - - - -	Leucophanite. - - - - - - - -	- - - - - - - - - - -	Serpentine. Retinalite.
1 : 1½	Gyrolite. Friedelite. Pyrosmalite. - - - -	- - - - - - - - - - - - -	- - - - - - - - - - -	Dewaylite. Genthite.
1 : 2	Xonaltite. Plombierite. Hydrorhodenite. Dioptase.	Wollastonite. Tscheffkinite. - - -	Amphibole. Rhodonite. Pyroxene. Enstatite. -	Aphrodite. Cerolite. Chrysocolla.
1 : 2½	Pectolite. - - - - - - -	- - - - - - - - - - - - -	Amphibole. - - - - - -	Spadaite.
1 : 2½	- - - - - - - - - - -	- - - - - - - - - - - - -	- - - - - - - - - - -	Rensselaerite.
1 : 3	- - - - - - - - - - -	- - - - - - - - - - - - -	- - - - - - - - - - -	Sepiolite. Glauconite.
1 : 3½	Datolite.			4. PROTOPHYLLOID.
1 : 4	Apophyllite. Okenite. - -	- - - - - - - - - - - - -	Guarinite. Titanite.	
1 : 7	- - - - - - - - - - -	- - - - - - - - - - - - -	Danburite.	Thermophyllite (3 : 4). Talc (3 : 5). Talc (3 : 6).

Suborder II.—PROTOPERSILICATE.

$m : m : si.$	6. ZEOLITOID. V = 7·2 — 6·2	7. PROTOPERSPATHOID. V = 3·6 — 6·1	8. PROTOPERADAMANTOID. V = 5·8 — 4·7	9. PROTOPERPHYLLOID. V = 6·2 — 5·1	
1 : ¼ : m	- - - - -	Melilite. Eudialyte. -	Pargasite. Keilhauite. - - - - - -	Phlogopite. -	CHLORITE. A large group of hydrous magnesian species.
1 : ½ : m	- - - -	Wöhlerite. Ilvaite. -	Idocrase. Schorlomite (4 : 3). - - -	Phlogopite. -	
1 : 1 : m	Xanthorthite.	Gehlenite. Sarcolite. Melilite. - - - -	Garnet. Ægirite, Allanite. Beryl. -	Biotite. - -	
1 : 1½ : m	Prehnite. - -	Barylite. - - - - -	Euclase. Ardennite. Arfvedsonite. -	Seybertite.	10. PINITOID.
1 : 2 : m	Hamelite. Catapleiite.	Scapolites. Sodalites.	Axinite. Epidote. Zoisite. Jadeite. Acmite. - - - - - - - - - -	Willcoxite. -	Jollyte.
1 : 3 : m	ZEOLITES. - -	FELDSPATHIDES. - - -	- - - - - - - - - - - Coronite.	Zinnwaldite.	Fahlunite. Bravaisite.
1 : 4 : m	Edingtonite. Sloanite.	Petalite. - - - - -	Spodumene. Sapphirine. Staurolite. - - - - Schorlite.	Lepidolite. -	Hygrophilite (1 : 5).
1 : 6 : m	Forestite. -	- - - - - - - - -	- - - - - - - - - - - -	Margarite. Muscovite.	
1 : 8 : m	- - - - -	- - - - - - - - -	- - - - - - - - - Aphrisite.	Euphyllite.	Pinite.
1 : 9 : m	- - - - -	- - - - - - - - -	- - - - - - - - - Indicolite.	Damourite. Muscovite.	Cossaite.
1 : 12 : m	- - - - -	- - - - - - - - -	- - - - - - - - - Rubellite.	Muscovite.	(Palagonite. Tachylite. Pitchstone. Obsidian.)
			TOURMALINES.	(With other species).	
			MICAS.		

Suborder III.—PERSILICATE.

m : si.	11. PERIDOLITOID. V = ——	12. PERISPATHOID. V = ——	13. PERADAMANTOID. V = 5·7—4·4	14. PERPHYLLOID. V = ——	15. ARGILLOID. V = 6·5—5·4
1 : ¼	- - - - - - -	- - - - - - -	- - - - - - - - - - - - -	- - - - - - - -	Schrötterite.
1 : ⅓	- - - - - - -	- - - - - - -	Dumortierite. - - - - - - -	- - - - - - - -	Collyrite.
1 : ½	- - - - - - -	- - - - - - -	{Topaz. Andalusite. Fibrolite. Cyanite. Wörthite (6 : 5). -}	- - - - - - - -	Allophane.
1 : 1	Westanite. - - -	- - - - - - -	{Bucholzite. Xenolite. Lyncurite. Zircon. Malacone.}	{Pholerite. Talcosite (5 : 6).}	Samoite.
1 : 1½	- - - - - - -	- - - - - - -	- - - - - - - - - - - - -	Kaolinite. - - - -	Kaolin. Halloysite.
1 : 1⅔	- - - - - - -	- - - - - - -	Auerbachite. - - - - - - -		
1 : 2	- - - - - - -	- - - - - - -	- - - - - - - - - - - - -	Pyrophyllite. - - -	{Keramite. Wolchonskoite.}
1 : 2½	- - - - - - -	- - - - - - -	- - - - - - - - - - - - -	Pyrophyllite. - - -	{Montmorillonite. Chloropal.}
1 : 3	- - - - - - -	- - - - - - -	Anthosiderite. - - - - - -	- - - - - - - -	Cimolite.
1 : 4	- - - - - - -	- - - - - - -	- - - - - - - - - - - - -	- - - - - - - -	Smectite.

IX. Orthography for Native Names of Places.

The Council of the Royal Geographical Society have adopted the following rules for such geographical names as are not, in the countries to which they belong, written in the Roman character. These rules are identical with those adopted for the Admiralty charts, and will henceforth be used in all publications of the society.

1. No change will be made in the orthography of foreign names in countries which use Roman letters: thus Spanish, Portuguese, Dutch, etc., names will be spelt as by the respective nations.

2. Neither will any change be made in the spelling of such names in languages which are not written in Roman character as have become by long usage familiar to English readers: thus Calcutta, Cutch, Celebes, Mecca, etc., will be retained in their present form.

3. The true sound of the word, as locally pronounced, will be taken as the basis of the spelling.

4. An approximation, however, to the sound is alone aimed at. A system which would attempt to represent the more delicate inflections of sound and accent would be so complicated as only to defeat itself.

5. The broad features of the system are that vowels are pronounced as in Italian and consonants as in English.

6. One accent only is used—the acute—to denote the syllable on which stress is laid.

7. Every letter is pronounced. When two vowels come together each one is sounded, though the result, when spoken quickly, is sometimes scarcely to be distinguished from a single sound, as in *ai*, *au*, *ei*.

8. Indian names are accepted as spelt in Hunter's "Gazetteer."

The amplification of the rules is given below :—

Letters.	Pronunciation and Remarks.	Examples.
a	*ah*, *a* as in *father*.....	Java, Banana
e	*eh*, *e* as in *benefit*.....	Tel-el-Kebir, Olé-feh, Yezo, Medina, Levuka, Peru

Letters.	Pronunciation and Remarks.	Examples.
i	English *e*; *i* as in *ravine*; the sound of *ee* in *beet*. Thus, not *Feejee*, but	Fiji, Hindi
o	*o* as in *mote*.....	Tokio
u	long *u* as in *flute*; the sound of *oo* in *boot*. Thus, not *Zooloo*, but.....	Zulu, Sumatra
	All vowels are shortened in sound by doubling the following consonant.	Yarra, Tanna, Mecca, Jidda, Bonny
	Doubling of a vowel is only necessary where there is a distinct repetition of the single sound.....	Nuulua, Oosima
ai	English *i* as in *ice*.....	Shanghai
au	*ow* as in *how*. Thus, not *Foochow*, but	Fuchau
ao	is slightly different from above.....	Macao
ei	is the sound of the two Italian vowels, but is frequently slurred over, when it is scarcely to be distinguished from *ey* in the English *they*.....	Beirut, Beilul
b	English *b*.	
c	is always soft, but is so nearly the sound of *s* that it should be seldom used. (*Celebes* should be written *Selebes*.).....	Celebes
ch	is always soft, as in *church*.....	Chingchin
d	English *d*.	
f	English *f*. *Ph* not to be used for the sound of *f*. Thus, not *Haiphong*, but	Haifong, Nafa
g	is always hard. (Soft *g* is given by *j*.).	Galapagos
h	is always pronounced when inserted.	
j	English *j*. *Dj* should never be put for this sound.....	Japan, Jinchuen
k	English *k*. It should always be put for the hard *c*. Thus, not *Corea*, but....	Korea
kh	The Oriental guttural.....	Khan
gh	is another guttural, as in the Turkish	Dagh, Ghazi
l, m, n	As in English.	
ng	has two separate sounds, as in *finger* and *singer*. As the sounds are rarely employed in the same locality, no attempt is made to distinguish them.	
p	As in English.	
q	should never be employed; *qu* is given as *kw*.....	Kwangtung
r, s, t, v, w, x	As in English.	
y	always a consonant, as in *yard*, and should not be used as a terminal,	
	i or *e* being substituted.....	Kikuyu
	Thus, not *Mikindany*, *Kwaly*, but	Mikindani, Kwale
z	English *z*.....	Zulu

X. Reviews and Book-Notices.

A Text-Book of Botany.*

Those who regarded this book with so much favor at the time of its previous issue, eight years ago, will doubtless be gratified that the fifth edition, with important revisions and additions, is now accessible. That a work which has so well filled an important place in botanical education, both in Europe and America, should be kept well abreast of the most recent developments of the science it represents, is particularly gratifying to those who have realized that the former edition was in many respects sadly behind the requirements of the day, almost as soon as issued, and the name of the English editor is sufficient guarantee that all reasonable effort would be made in this direction.

The ground covered is extensive, dealing as it does with the whole range of botanical science from histology to geographical distribution; and to comprise so much within the narrow limits of an octavo of 480 pages has necessitated great abbreviation, often when it would seem exceedingly desirable that more detailed consideration should be given. Thus the very important results recently developed concerning the continuity of protoplasm, are dismissed (p. 31) with a brevity which must certainly leave a very unsatisfactory impression on the mind of the student. Again, concerning the movement of water, (p. 161) the student gains but a superficial knowledge of the forces actually at work and the way in which they operate, when it is stated that: "The roots absorb a greater quantity of water than the plant requires, and this therefore exercises a pressure which drives the water that has been already absorbed, higher and higher up the stem,"—a statement which is much too general to be exact, and which, in the second place, gives the student no possible clue to the well-known fact, that this root-pressure is largely subordinate to other forces when the plant is in a condition of active transpiration. Also, one is not informed of the important distinction which must be made between the flow of sap which is purely mechanical and that which is of a more strictly physiological nature. Thus, the impression is given (p. 161) that the bleeding of trees is due to

* Text-Book of Structural and Physiological Botany. By Otto W. Thomé and A. W. Bennett. Fifth edition 8vo., pp. 480. Longman, Green & Co., London.

the special abundance of sap in spring, whereas it is now a well known fact that such bleeding occurs only when there is great variation in temperature; that it may occur at any time during the rest period, if the external conditions are favorable; and that it most generally occurs at a time when the tree contains its minimum of water, ceasing as soon as the leaves develop, and therefore not appearing when there is a maximum of water in the tissues and the greatest physiological movement of water to the leaves and growing parts. These faults, while they are serious for the student who desires to pursue an independent course of study, would largly disappear under the guidance of a competent teacher, but they should be eradicated as far as possible.

While we regret the exceeding brevity which seems to be forced upon the author, this finds some compensation in the remarks of the translator when he says: "It cannot be too strongly impressed upon the student that a mere book knowledge of this, as of any other science, is absolutely valueless. He must make himself practically acquainted with the aid of the microscope, and, if possible, under the guidance of a competent teacher, with the minute structure of plants, and with the life history of the various forms." This is the view which it is important to emphasize and impress upon students and also teachers of graded schools where such subjects find an important place in the course of study. In this light, the treatment of the various subjects may be considered to serve the purpose very well.

In classification many important changes have been made, bringing this subject fairly well abreast of recent developments. In the general morphology there is a tendency to the introduction of rather more technical terms than is wholly desirable, tending to create confusion in the mind of the young student.

Taken as a whole, this edition may be regarded as a useful addition to the general text-book series, and will doubless be found to meet a very general demand.

D. P. P.

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*The Report of the Kansas State Horticultural Society** is a most hopeful indication of what American horticulture is likely to become in the future. The contents are of a much more

* Kansas State Horticultural Society, Annual Report. G.C. Brackett, 8vo., pp. 306. 1884.

substantial character than is generally found in such publications and embrace much that is of a valuable scientific nature. Many of the articles were presented at the New Orleans meeting of the American Horticultural Society, and are from the pens of men well qualified to bring scientific dignity to such discussions and publications. That science is gradually being more and more appealed to by such Societies, becoming daily more closely identified with their work, and more of a recognized necessity in meeting the practical problems of the horticulturist, is a source of great gratification, and progress in this direction cannot be made more directly and efficiently than by such efforts as are apparent in the Report now before us.

We have received a little reprint from the Tenth Annual Report of the Montreal Horticultural Society, *On the Establishment of a Botanic Garden in Montreal*, containing a large amount of useful information concerning botanic gardens in other parts of the world, of which it enumerates a total of 187. It is well worthy of careful perusal. Its chief object appears to be to supply arguments showing the necessity of a Botanic Garden in Montreal. The subject is dealt with in all its aspects, and, aside from the purely scientific value of such institutions, which it clearly demonstrates, not the least valuable is the very interesting influence which gardens of such a character are found to have upon the public, in establishing higher ideals of nature and a better moral sentiment.

XI. Obituary.

H. Milne Edwards.

After a life of eminent service as one of the leading naturalists of his day Dr. H. Milne Edwards died at Paris, July 9th, in the eighty-fifth year of his age. He was elected an honorary member of Montreal Natural History Society in 1852.

Though resident in Paris from an early age, he was born at Bruges, Belgium, of English parentage, in the year 1800. His investigations began at an early age and led directly up to the crowning work of his life, his "Comparative Physiology and Anatomy," upon the completion of which, in 1881, he was presented with a medal, subscriptions to which were contributed by men of science in all parts of the world, as a modest tribute to his high

scientific attainments. His well-recognized merits as a Zoologist resulted in his election to the chair of Zoology at the Museum of the Academy of Sciences, as the successor of Geoffrey St. Hilaire. His son, A. Milne Edwards, is following the same line of research as his father, with much of the ability and thoroughness which characterised the latter.

Miscellaneous Notes.

Anthropological.—*The Physical Characteristics of the Natives of the Solomon Islands.*—On June 23rd, at the Anthropological Institute of London, Mr. H. B. Guppy read a paper on the above subject, giving the results of observations made during the years 1881–1884. The typical Solomon Island native (male) is well-proportioned, with a height of about 5 ft. 3 in., a weight of 125 to 130 lbs., and a chest-girth between 34 and 35 in., whilst the color of his skin is a deep brown, corresponding with color type 35 of M. Broca. Considerable variety, however, prevails in the physical characters of these natives, and it was shown, by comparing the inhabitants of the islands of Bougainville Strait with those of St. Christoval and its adjoining island at the opposite end of the group, that in the former locality there exists a taller, darker, and more brachycephalic race, whilst in the latter mesocephaly prevails, and the average native is rather shorter and of a lighter hue. The color of the skin varies considerably throughout the group, from a very deep brown to a light copperish hue, the range being represented by color types 42 and 29, with their intermediate shades. The author arrived at the conclusion that, although mesocephaly and brachycephaly most frequently characterise these people, the form of the skull varies beteween too wide limits to allow of one particular type being referred to this group. The range of the cephalic indices calculated from these measurements is 69 to 86, and the greater number are gathered in two groups, one around the indices 74 and 75, and the other around the indices 79 and 80.—*Athenæum.* (R.W.B.)

The Report of the Council at the Annual Meeting of the Folk-Lore Society of London, June 27th, contained the following definitions of Folk-lore by different members, with suggested divisions of the subject:—Mr. Nutt, "Anthropology dealing with primitive man"; Mr. Hartland, "Anthropology dealing with the psychological phenomena of uncivilised man"; Mr. Gomme, "the Science which treats of the survivals of archaic beliefs and customs in modern ages"; Miss Burne, "the Science with treats of all that the Folk believe or practice on the authority of inherited tradition, and not on the authority of written records"; Señor

Machado y Alvarez, "(1) Demo-Psychology, or the science which studies the spirit of the people; and (2) Demo-Biography, which is the description of the mode of life of the people taken in the aggregate." The council also brought forward several suggestions made by Don Machado y Alvarez, (1) that an International Congress of Folk-lorists should be held in London in June, 1888, being the tenth anniversary of the foundation of the Society; (2) that a Committee should be appointed to study children's games and the language of children, for which the lady members might lend their assistance; (3) that photography should be applied to the games, festivals and popular types of all the districts of England.—*Academy*. (R.W.B.)

BOTANICAL.—*Chemistry of Chlorophyll.*—After separating the phyllocyanin and phylloxanthin by Fremey's method, the author points out the special reactions of the former. It is insoluble in water, petroleum, ether and ligroin, but soluble in alcohol, ether, chloroform, glacial acetic acid, benzol, aniline and carbon disulphide, the best solvent being chloroform. A very small quantity of the phyllocyanin imparts an intense color to all of these solvents, but when very largely diluted the solutions lose their opacity. Oxidising agents easily decompose it, yielding yellow, amorphous products, the solutions of which show no absorption bands, but it is more permanent than chlorophyll when exposed to the combined action of air and light. Phyllocyanin dissolves in concentrated sulphuric, hydrochloric and hydrobromic acids, yielding dark blue solutions, but these compounds are unstable, the addition of water precipitating the phyllocyanin unchanged. The latter has no tendency to combine with weaker acids, such as oxalic, tartaric, acetic, phosphoric, etc. Phyllocyanin readily dissolves in caustic potash or soda, from which precipitates of various shades of green may be obtained with earthy and metallic salts, such as barium chloride, calcium chloride, acetate of lead, acetate of copper, etc. Solutions in alkali involve some change in the phyllocyanin.—E. SCHUNCK, *Nature*, xxxii. 217. (D. P. P.)

Colorless Chlorophyll.—C. Timiriazeff points out that he has quite recently determined that, when a chlorophyll solution is treated with metallic zinc and an organic acid, it is reduced through the agency of the nascent hydrogen generated in the reaction, the resulting substance being perfectly colorless and presenting no traces of the characteristic chlorophyll spectrum or fluorescence. It is only in coming in contact with air that it gradually acquires its green color and specific optical properties. He considers that this discovery is an additional proof in favor of a hypothesis announced by him in 1875, viz., that the green color of this substance is due to iron in the state of a $FeOFe_2O_3$ compound. Since the product of reduction is colorless and

produces no dark line in the spectrum, he regards the reduction of chlorophyll, when CO_2 is dissociated through the agency of light, as sufficient reason why the transformation may not be attended by a visible change of its color and other optical properties.—*Nature*, xxxii. 217, 342. (D. P. P.)

The Eucalyptus in Italy.—According to a writer in the "Gartenzeitung" of Berlin, the plantations of the Eucalyptus in Italy have been far from realising the results that were anticipated from them, as a means of preventing malarious fever, and neither the soil nor the climate of that country appears to be favorable for the growth of this tree, and he recommends the *Quercus rex*, the *Laurus glandulosa*, and certain varieties of the maple as being far better suited for the purpose. Another authority, Dr. Dieck, recommends the *Acer californiense*, a tree of nearly as rapid a growth as the Eucalyptus, the *Acer macrophyllum* of California, the *Acer insigne* of the Himalayas, all of which are well suited forcultivation in malarious districts in Italy; the *Salix babylonica*, *Populus angulata*, *heterophylla*, etc., are all said to be preferable to the Eucalyptus, and more suitable to the climate, and contain similar properties to those of the Eucalyptus, to which it owes its efficiency as a preventive against the malaria. Dr. Dieck, however, considers that the root of the evil lies in the indiscriminate cutting down of the trees on the mountains, and that their re-wooding would do far more towards checking malaria than any measures taken in the marshes, which districts have been reduced to their present state by forestal mismanagement and neglect. (A.H.M.)

CHEMICAL AND PHYSICAL.—*Apomorphine as an Anæsthetic.*—Professor Ludwig, aided by M.Bergmeister, has instituted a series of experiments upon a great number of organic substances in search for a body possessing powers similar to cocaine. Their investigations were fruitless until they tried apomorphine, which drug they found to be almost, if not quite, equal to cocaine in point of local anæsthetic properties. Their experiments were made on cats with a 2 per cent solution of apomorphine hydrochloride. (A.H.M.)

A New Reagent for Distinguishing Alcohols.—As a reagent for distinguishing alcohol obtained from potato spirit from the pure alcohol obtained from corn, etc., Dr. Hager (*Pharm Central*, xxvi. 26) proposes a 10 per cent. solution of mercurous nitrate. One-part crystallized nitrate is dissolved in 10 parts distilled water and rendered clear by the addition of a trace of nitric acid and allowed to settle over some metallic mercury. When 3 drops of the solution are added to 3 cc. (about 50m.) of absolute or 94 per cent. alcohol, a milky mixture with a yellowish white tinge results upon agitation. Upon several hours'

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EDITORIAL.

The editors of THE CANADIAN RECORD OF SCIENCE take the present opportunity, the editorial staff having been materially changed, to appeal to Canadian scientists to support the management in their endeavour to make the RECORD a worthy exponent of Canadian science.

In furtherance of this object, scientific articles of merit will be welcomed from all parts of the Dominion and United States; and it is hoped that those, who are in a position to make observations of natural phenomena, will at once communicate such facts to the RECORD for publication.

All communications should be addressed to the editors, 32 University Street, Montreal. The authors of articles that are accepted will receive twenty reprints gratis, and may obtain additional copies at a reasonable rate by notifying the editors of the number required when proofs are forwarded. Rejected articles will be returned, if a request to that effect is made and postage-stamps are enclosed.

Members of the Natural Society, paying a subscription of $4.00, are entitled to receive the RECORD. Non-subscribers to the Society may obtain it at the rate of $3.00 per volume. As however, it has been deemed advisable to close the First Volume of the RECORD with the present number, those who have paid the full subscription of $3.00 for the current volume will be entitled to receive the Second Volume, the first number of which will be issued in January, 1886, by payment of an additional subscription of $1.50.

The attention of Subscribers is requested to the list that appeared in our last number. Any names there omitted will be added; and it is hoped that those, who fail to receive their numbers with regularity, will call the attention of the editors to the fact.